Marshall Cavendish Education

Cambridge Assessment International Education

Endorsed for full syllabus coverage

Cambridge IGCSE™ Biology

STUDENT'S BOOK

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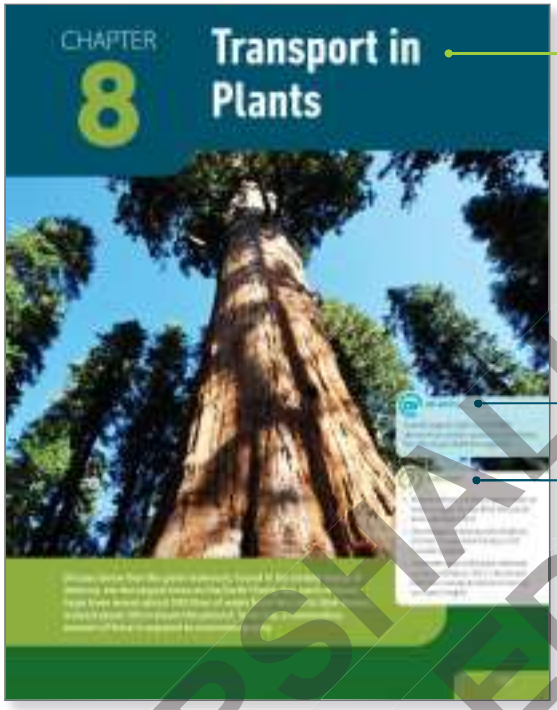
How to Use This Book

This book is designed to help you to build your knowledge and understanding of essential scientific concepts. It will also enable you to appreciate the application of Biology in your everyday life and in the world around you. This Student's Book is part of the Marshall Cavendish Education suite of resources that will support you as you follow the Cambridge IGCSE™ and IGCSE (9–1) Biology (0610/0970) syllabuses and prepare for your examinations.

Note:

- Features indicated as 'Option' provide additional content and context to help enhance and enrich your learning, including some contexts that extend beyond the requirements of the syllabus. You can decide to skip 'Option' content and still fulfil the syllabus requirements.
- Contents in some features within the book includes elements that are beyond the syllabus. This is indicated by an asterisk (*).
- Some content within the main body text is not required in the syllabus but is very useful to enhance and provide complete understanding. This will be indicated using triangle symbols before (▶) and after (◀) the text.



Chapter opener page [Option] introduces the topic and links concepts to real-life examples.

BIO WATCH [Option]

provides multimedia resources, such as videos, animations and simulations, making learning 'come alive'. The resources can be launched on a smartphone or a tablet by scanning the page using the ***MCE Cambridge IGCSE App***. Please refer to www.mceapps.com for user guide and further information.

QUESTIONS [Option]

assesses your prior knowledge on the topic.

Learning aims help you identify areas of focus and serve as a checklist.

QUICK CHECK

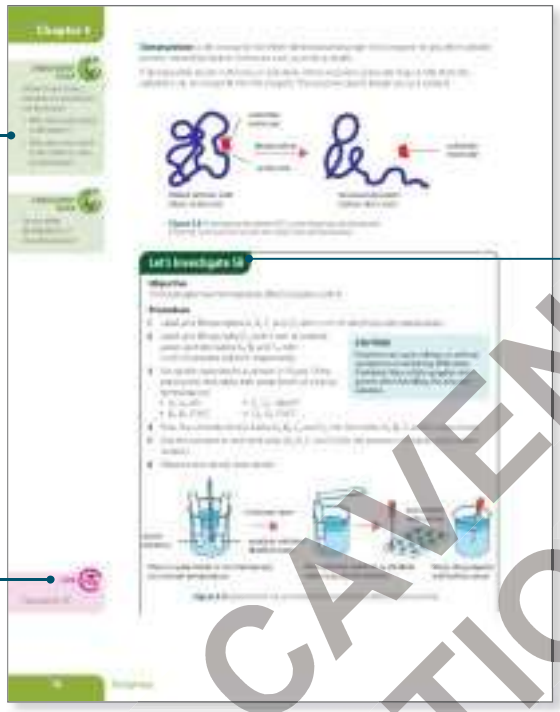
serves as a checkpoint to check your understanding of concepts by posing a true or false question. Rate your confidence level in your answer by drawing a pointer on the confidence meter. Relating your answer and confidence level to the correct answer helps you to detect any lack of knowledge or potential misconceptions. For example, high confidence in an incorrect answer could suggest a misconception and low confidence in a correct answer could suggest a lack of knowledge.

Headings are often posed as questions so that information is always directed towards helping you to answer essential questions about the topic.

How to Use This Book

[Option] **ENRICHMENT** *THINK*

poses challenging questions that encourage you to apply the concepts learnt to various contexts and prompts higher-level critical thinking.



LINK PWB

leads you to practicals in the Practical Workbook.

Let's Investigate

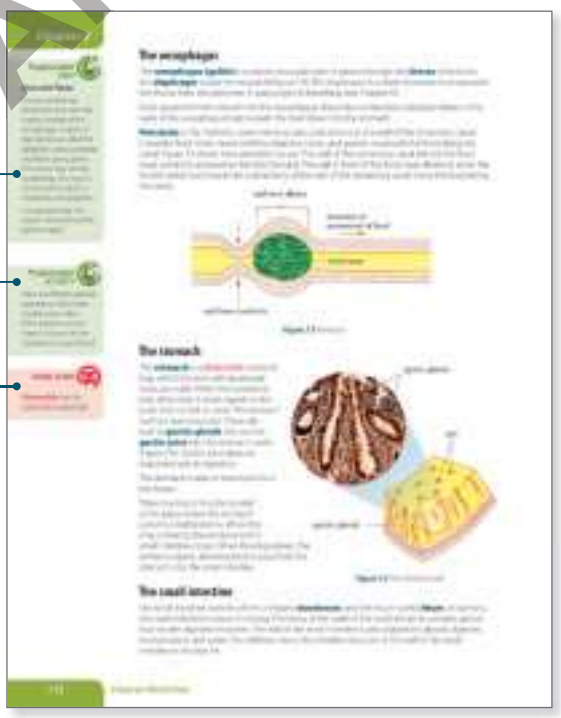
introduces experimental skills and techniques, and allows you to see how concepts are formed and tested.

[Option] **ENRICHMENT** *ACTIVITY*

provides individual and group activities that encourage deeper thought to help reinforce your learning.

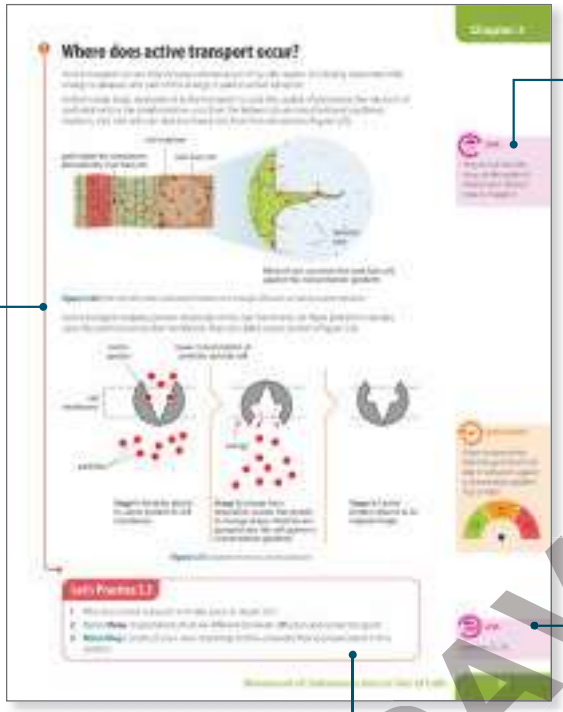
[Option] **ENRICHMENT** *INFO*

offers snippets of information to supplement your general knowledge and provide additional context related to the topic.



WORD ALERT A-Z

explains words in a simpler way to help you understand their meanings in context. This also helps you to be more familiar with the words and be confident in using them.



LINK

helps you make connections between sections or chapters.

LINK

leads you to the revision exercises in the Theory Workbook.

Supplement content is clearly marked for those studying the extended syllabus

Let's Practise

provides formative assessment questions at the end of sections to test your ability to recall and apply concepts learnt.

HELPFUL NOTES

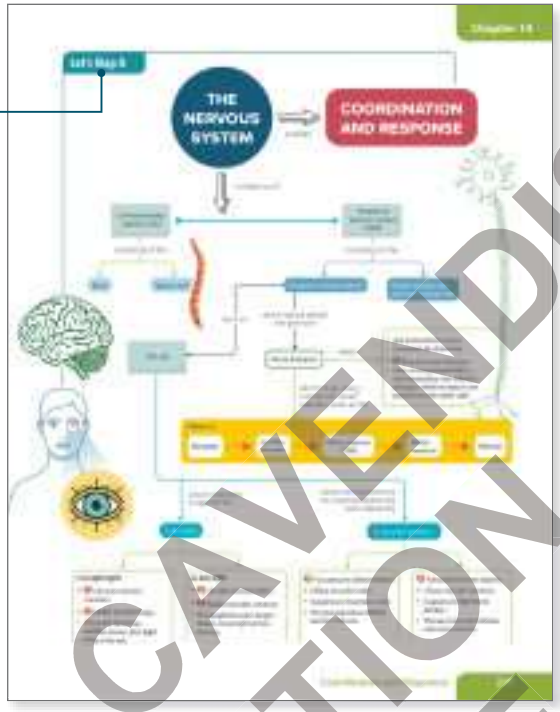
supports your learning by providing tips, such as mnemonics, and highlighting important notes that you need to be aware of.

Worked Example

demonstrates how to solve problems by applying concepts learnt.

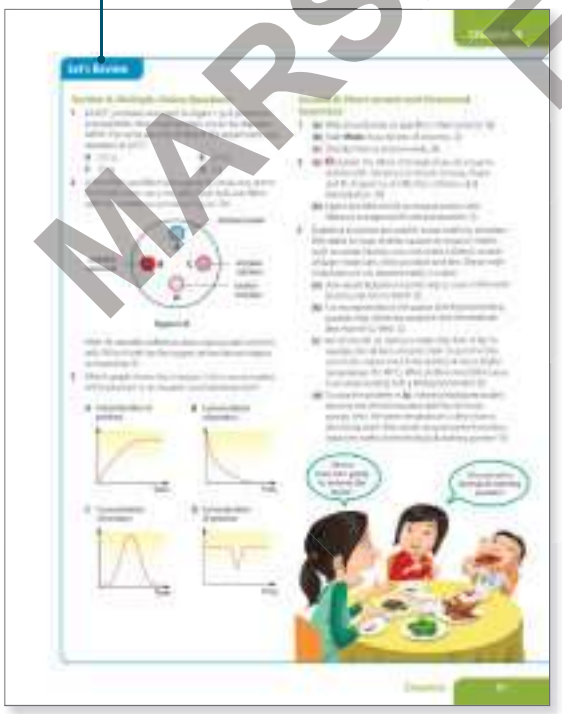
Let's Map It

provides a visual summary of the concepts covered to help you integrate your learning and form connections between different concepts.



Let's Review

offers summative assessment questions to test your understanding and gives you practice in answering exam-style questions.



The following are also included at the end of the book:

Notes to Biology Practical Work – provides information on laboratory safety, some common experimental contexts in practical work and the practical skills involved in the planning of experiments and investigations

Quick Revision Guide – lists each chapter's key concepts and formulae for easy revision

Answers – provided for questions in Quick Check, Let's Practise and Let's Review

Index – provided to help you search for key terms and phrases in the book

Contents

CHAPTER

1

Characteristics and Classification of Living Organisms

BIO WATCH

Scan this page to watch a clip on the *Lithops* plant.

QUESTIONS

- What makes something a living thing?
- Do non-living things share any of the characteristics of living things?
- Both a cat and a robot can move. Are both living things?

Look at the picture. Can you tell which "stones" are alive?

Often known as a living stone, a *Lithops* plant has thick fleshy leaves that look deceptively like a split stone. Although it has a stone-like appearance, a *Lithops* plant has certain characteristics in common with all other living things.

1.1 Characteristics of Life

In this section, you will learn the following:
- Describe the characteristics of living organisms.

What is life?

Biology is the science of life. It involves the study of living things. However, what defines life? What distinguishes living things from non-living things?

Biologists are scientists who study living things. It is not easy to give an exact definition of the term *life*. Through observations and experimentations, biologists have identified certain characteristics common to all living things or **organisms**. We say that these are the characteristics of living organisms, or the **characteristics of life**.

ENRICHMENT *ACTIVITY*

Observe the living things around you. Compare them with non-living things. Write down a list of characteristics that living things have in common. Compare your list with the characteristics that follow. In what ways are living things different from non-living things?

What are the characteristics of life?

Cells

All organisms are made up of simple units called **cells**. The cells of an organism carry out activities necessary for the organism to stay alive (Figure 1.1). A cell is a unit of life.

Non-living things are not made up of cells.

Figure 1.1 *Cells in the leaves of plants carry out photosynthesis.*

Nutrition

Living organisms need energy to stay alive. They also need nutrient molecules to make the living matter in cells.

Nutrition is the taking in of materials for energy, growth and development.

The basic difference between plants and animals is how they carry out nutrition. Plants take in raw materials (carbon dioxide and water) to make food through **photosynthesis**. Animals cannot make their own food. They have to feed on plants or other animals to survive, grow and carry out their daily activities.

Non-living things do not require nutrition. A piece of filter paper can absorb water and a solution of mineral ions. However, unlike a living organism, it is unable to chemically convert the substances it has absorbed into a part of itself.

Respiration

Many chemical activities occur in the cells of living organisms. These are called metabolic activities or **metabolism**. Energy is required for metabolic and other activities such as growth and development. Living organisms obtain energy through respiration. Energy is released when nutrient molecules such as glucose are broken down during respiration.

Respiration is the breakdown of nutrient molecules in cells to release energy for metabolism.

Excretion

Many different metabolic activities occur in cells. These metabolic activities may produce substances that can be harmful if they accumulate in the body. These substances are called metabolic waste products. Sometimes, there may be substances that are in excess of what the body needs. For example, too much or excess ions in the bloodstream can cause water to pass out of the cells into the bloodstream. As a result, the cells will dehydrate.

These metabolic waste products and excess substances must be removed.

Excretion is the removal of metabolic waste products and substances in excess of the body's requirements.

Most animals have special organs for removing their excretory products. For example, carbon dioxide, a waste product of respiration, is excreted from our body through the lungs. Plants also excrete waste products. Oxygen produced during photosynthesis is excreted out through the leaves (Figure 1.2).

Figure 1.2 *We need oxygen to break down glucose in our bodies during respiration. Oxygen is a by-product of photosynthesis. Our survival depends on a gas excreted by plants!*

WORD ALERT

Dehydrate: lose a large amount of water

LINK

What are the organs involved in excretion and their excretory products? Find out in Chapter 13.

QUICK CHECK

Plants do not excrete waste products, but animals do.

True or false?

WORD ALERT A-Z

Dry mass: mass after water content is removed

Growth and development

Growth is the permanent increase in **dry mass** and size of an organism.

When absorbed food is converted into living matter in the cells of an organism, some of the new matter formed is used to repair worn-out parts of the cells. The rest is added to the original living matter. This increases the size of the individual cells. As living organisms grow, their cells also divide to form more cells, making the body larger. Did you know that you started off life as a single cell, less than 1 mm in diameter? Now, you are a large organism made up of billions of different kinds of cells!

Living organisms grow as well as develop. **Development** may make an organism become more complex and change in form. For example, a seed germinates into a seedling and then grows and develops into a mature plant. The egg of a butterfly hatches into a caterpillar, grows and develops into a pupa, and finally emerges as a butterfly (Figure 1.3).

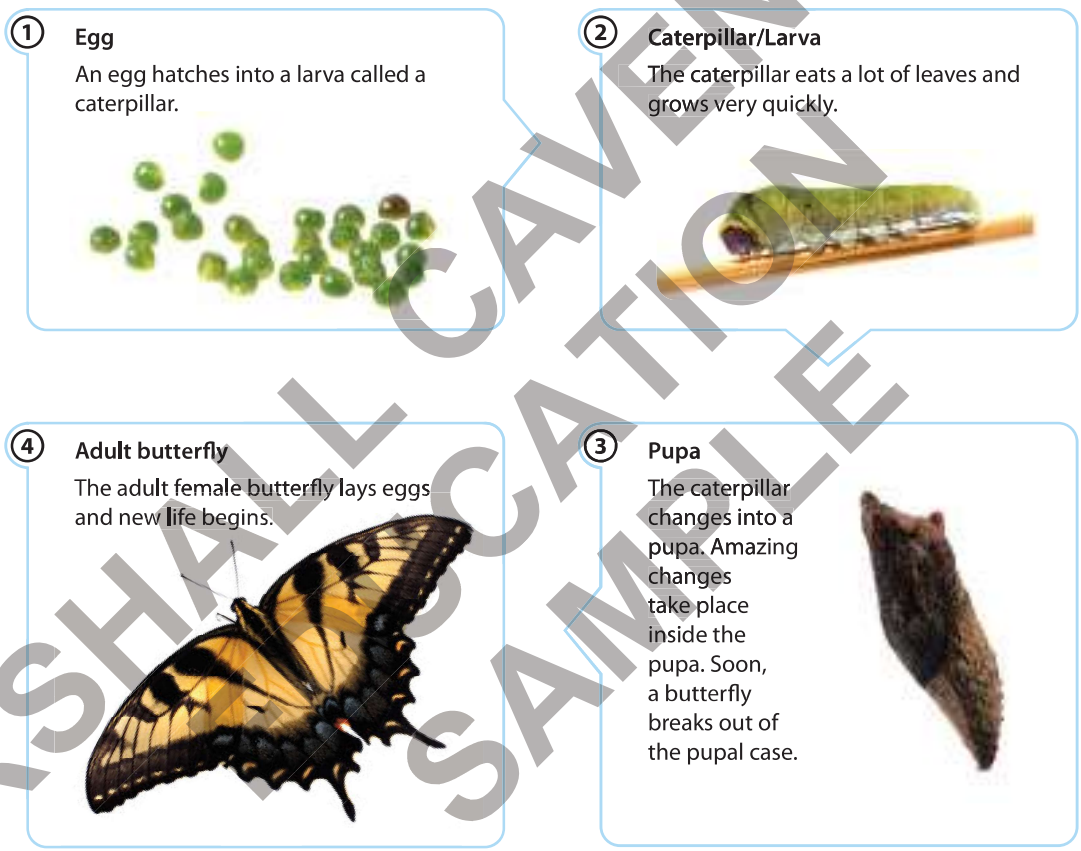


Figure 1.3 *The body of a caterpillar becomes more complex as it grows and develops into a butterfly.*

A non-living thing such as a bicycle does not grow. However, a crystal immersed in a saturated solution may increase in size. How is this change different from that of a living organism?

Movement

Movement is an action by an organism or a part of an organism, causing it to change its position or place.

It is easier to detect movement in animals than in plants. Most animals are able to move from one place to another. Such movement is called **locomotion**. Some animals do not have the ability to locomote. For example, corals and sponges are fixed to one place (Figure 1.4). However, they can still move parts of their bodies.

Figure 1.4 *Corals do not move from place to place.*

Most plants are unable to locomote but their parts are always moving slowly. The flowers of plants slowly open, and their shoots bend towards the light as they grow.

Reproduction

Organisms are mortal. They die of diseases, old age or in accidents, or are eaten by other organisms. Thus, reproduction is necessary for any kind of organism to survive (Figure 1.5).

Reproduction is the process that makes more of the same kind of organism.

Figure 1.5 *Living organisms reproduce to ensure the continuity of their own kind.*

Sensitivity

Animals and plants are sensitive to changes in their environment. They can detect and often respond to these changes in ways that are beneficial to them.

Organisms are able to respond to changes in their external environment. The following are some examples:

- Cockroaches forage in a dark room but will immediately hide when the light is turned on.
- When we smell something unpleasant or touch something very hot, we will immediately move away from it.
- When the sensitive plant *Mimosa pudica* (touch-me-not) is touched, its leaves automatically fold up (Figure 1.6).

Figure 1.6 *Mimosa pudica responds to touch by folding its leaves.*

Organisms are also able to respond to changes within themselves. When we perform vigorous muscular exercises, heat is released in our body. Our nervous system detects such a change and causes us to sweat more. As water in the sweat evaporates, excess heat is removed, preventing our body from overheating.

Sensitivity is the ability of an organism to detect and respond to changes in the external or internal environment.

What are the differences between a living organism and non-living matter?

Some of the characteristics of living organisms can be found in certain non-living matter. For example, a motorcar can move and give off waste products when its fuel is burnt. It also has a well-organised and complex structure. In fact, scientists often use machines as models to help them understand how living organisms work. However, machines cannot reproduce and they cannot grow.

All the characteristics of life must be considered when distinguishing between a living organism and non-living matter.

Let's Practise 1.1

1 List the characteristics that differentiate a living organism from non-living matter.

2 **Mind Map** Construct your own mind map for the concepts that you have learnt in this section.

LINK TWB
Exercise 1A

1.2 Classifying Living Organisms

In this section, you will learn the following:

- State that organisms can be classified based on the features they share.
- (S) Explain that classification systems are useful in providing evolutionary relationships among organisms.
- Describe what a species is.
- Describe the binomial system of naming species.
- State the main features of the animal kingdom and the plant kingdom, and classify organisms into the correct kingdom using the features.
- (S) State the main features of each of the five kingdoms, and classify organisms into the correct kingdoms using the features.
- (S) State the features of viruses.
- State the main features of the major groups of vertebrates and arthropods, and classify animals into the correct groups using the features.
- (S) State the main features of ferns and flowering plants (monocotyledons and dicotyledons), and classify plants into the correct groups using the features.
- Construct and use dichotomous keys.

There are millions of kinds of living organisms on the Earth. In order to study them systematically, biologists put living organisms into groups according to their similarities and differences. Organisms are classified based on the features that they share. This is called **classification**. In 1753, the Swedish naturalist, Carolus Linnaeus, devised a system of classification, which is still used today.

(S) How is classification useful?

Classification systems are useful in providing information on **evolutionary** relationships among organisms. Biologists use features that may throw some light on the origin of living organisms — how they come to be on Earth and how they are related. For example, careful examination of the skeletons of the fins of fish, the wings of birds and the limbs of mammals shows that their bones are arranged in a similar pattern. This suggests that the organisms descended from the same ancestor. The reason why they differ from one another is that they have evolved with modified structures to carry out different functions, such as swimming, flying and walking.

WORD ALERT

Evolutionary: the gradual process of change and development of a living organism from an earlier form

The biological system of classification

The natural (biological) system of classification puts organisms into groups based on their similarities and differences. This system is easy to refer to when identifying organisms.

LINK

Comparing the DNA of organisms is an example of a classification system. Find out more about this in Chapter 4.

Figure 1.7 shows how organisms are classified using this system of classification.

Organisms are first divided into **kingdoms**, such as the plant kingdom and the animal kingdom.

▶ Within each kingdom, organisms are further classified into several phyla (singular: phylum). ◀

▶ A phylum is made up of several classes. ◀

▶ Each class is made up of orders. ◀

▶ Each order is made up of families. Within each family, the organisms resemble one another fairly closely. ◀

Each family consists of a varying number of **genera** (singular: **genus**).

A genus has usually several species. A **species** is a group of organisms that can breed with one another to produce fertile offspring.

Figure 1.7 *The biological system of classification*

▲ Gentoo penguin, *Pygoscelis papua*

▼ Adelie penguin, *Pygoscelis adeliae*

Figure 1.8 *Two different species of penguins*

In the biological system of classification, living organisms are classified according to a graded scale or **hierarchy**. As we go down the hierarchy, the resemblance between organisms becomes much closer. For instance, it is easy to distinguish one family from another or separate different genera. However, it may be more difficult to differentiate between species (Figure 1.8).

QUICK CHECK

The biological system of classification is hierarchical, starting from the largest group.

True or false?

How do we name a species?

The common name used to refer to a species may vary in different parts of the world. This can cause confusion. Carolus Linnaeus used Latin to give two names to each species. This naming system is called the **binomial system of naming species**. It is an internationally agreed system.

- The first name refers to the genus to which the organism belongs. It always starts with a capital letter.
- The second name is the species name. It starts with a small letter.
- Both the genus and species names are either *italicised* or underlined.

For example, the domestic cat belongs to the genus *Felis* and the species *domestica*. Therefore, its scientific name is *Felis domestica* or Felis domestica (Table 1.1).

HELPFUL NOTES

We underline the scientific name when it is not possible to write in italics.

Table 1.1 *The binomial system of naming species*

First name: Genus	Second name: Species
Felis	*domestica*

What are the kingdoms of living organisms?

Biologists in general recognise five kingdoms of living organisms — **Prokaryote**, **Protoctista**, **Fungi**, **Plantae** and **Animalia**. Figure 1.9 shows the five kingdoms, their main features, and some main groups of plants and animals.

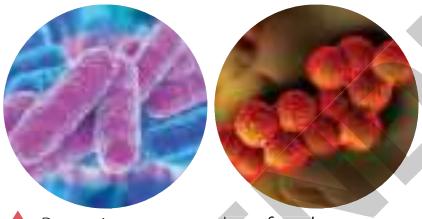
LINK

How are plant, animal and bacterial cells different? Find out in Chapter 2.

Kingdoms

Prokaryote

Prokaryotes, which include bacteria, are unicellular organisms (made up of one cell). Bacteria have a circular DNA and a cell wall made of murein. They have no nucleus and no membrane-bound structures.



Bacteria are examples of prokaryotes.

Protoctista

Protoctists are mostly aquatic. They are unicellular organisms, but some, such as seaweeds, are multicellular (made up of many cells). They have cells with a nucleus and membrane-bound structures. Some have a cell wall and contain chlorophyll to make food by photosynthesis.

Paramecium, amoeba and sea lettuce are examples of protoctists.

Fungi

Fungi can be unicellular or multicellular. They have cells with a nucleus and a cell wall made of chitin. However, they do not have chlorophyll. Some fungi feed on decaying matter, while some are parasitic (live and feed on other living organisms).

Bracket fungi, mushrooms and mould are examples of fungi.

Plantae

Plants are multicellular organisms which have cells with a nucleus, a cell wall made of cellulose and a large central vacuole. They contain chlorophyll to make food by photosynthesis.

- Ferns
- Flowering plants
  - Classes
    - Monocotyledons
    - Dicotyledons

Animalia

Animals are multicellular organisms which have cells with a nucleus but no chlorophyll or cell wall. They obtain energy and nutrients by feeding on other organisms.

- Arthropods (Invertebrates)
  - Classes
    - Crustaceans
    - Myriapods
    - Arachnids
    - Insects
- Vertebrates
  - Classes
    - Fish
    - Amphibians
    - Reptiles
    - Birds
    - Mammals

Figure 1.9 Some main groups of living organisms

What are viruses?

In addition to the five kingdoms of living organisms, there are viruses — the smallest "organisms" (Figure 1.10).

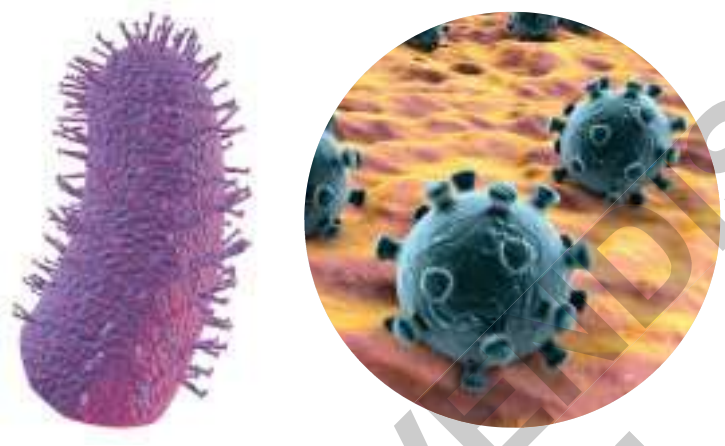


Figure 1.10 Different kinds of viruses

A **virus** consists of genetic material enclosed by a protein coat, as shown in Figure 1.11. Viruses are on the borderline of the living and non-living worlds. Viruses do not feed, respire, excrete and grow. On their own, viruses do not reproduce. However, once they enter a living organism, they can multiply rapidly.

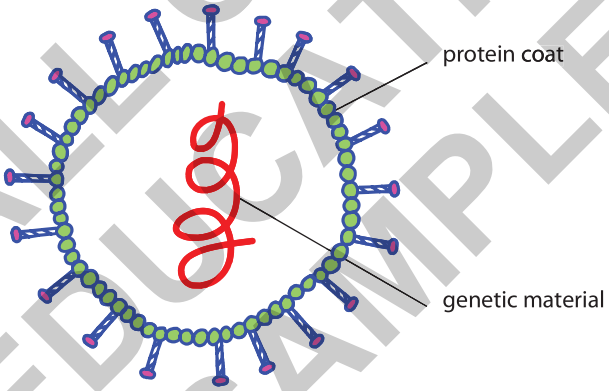


Figure 1.11 Structure of the virus that causes measles

How do we classify plants?

The plant kingdom can be divided into several major groups, which include flowering plants and ferns.

Flowering plants

Many plants around us are flowering plants. **Flowering plants** have these main features:

- Have roots, stems and leaves
- Produce flowers and seeds
- Reproduce by seeds

Flowering plants can be further divided into two main groups or classes — monocotyledons and dicotyledons (Table 1.2).

Table 1.2 *Main features of monocotyledons and dicotyledons*

Monocotyledons (Examples: Maize, grass, sugarcane)	Dicotyledons (Examples: Balsam, *Hibiscus*, Angsana)
They have one cotyledon in the seed.	They have two cotyledons in the seed.
They have parallel leaf veins and often have long, narrow leaves.	They have net leaf veins and often have broad leaves.
They have fibrous roots.	They have taproots.

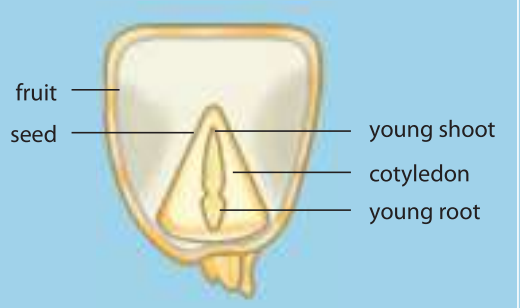


Figure 1.12 *Maize fruit*

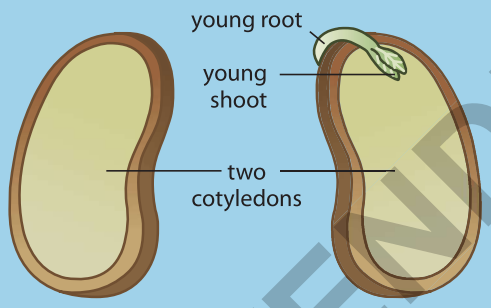


Figure 1.13 *Bean seed with two cotyledons separated*

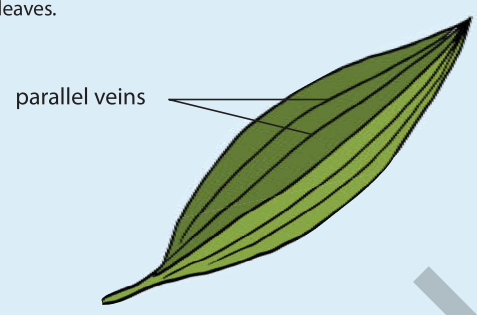


Figure 1.14 *Leaf with parallel veins*

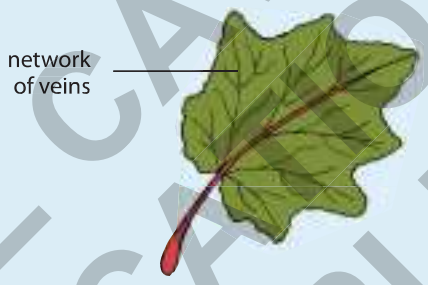


Figure 1.15 *Leaf with net veins*

Figure 1.16 *Fibrous root*

Figure 1.17 *Taproot*

Ferns

Ferns are spore-producing plants (Figure 1.18) with these main features:

- Have roots, stems and leaves
- Do not produce flowers or seeds
- Reproduce by spores

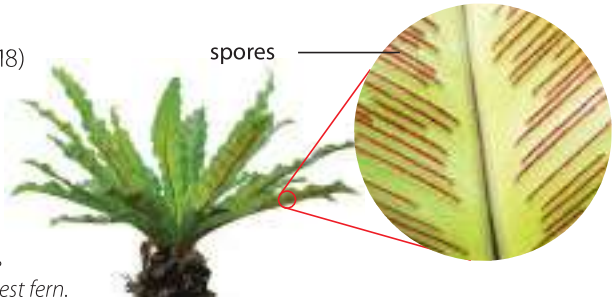


Figure 1.18 *Spores are found in parallel rows on the underside of the leaves (called fronds) of the bird's nest fern.*

How do we classify animals?

As we have seen in Figure 1.9, arthropods and vertebrates are two major groups of animals.

Arthropods

Arthropods are animals without a vertebral column (or a backbone). They are also called **invertebrates**. The main features of arthropods include

- segmented bodies;
- jointed limbs (legs);
- bodies covered with exoskeleton (outer skeleton made of chitin).

Crustaceans, myriapods, arachnids and insects are four main groups or classes of arthropods (Figure 1.19).

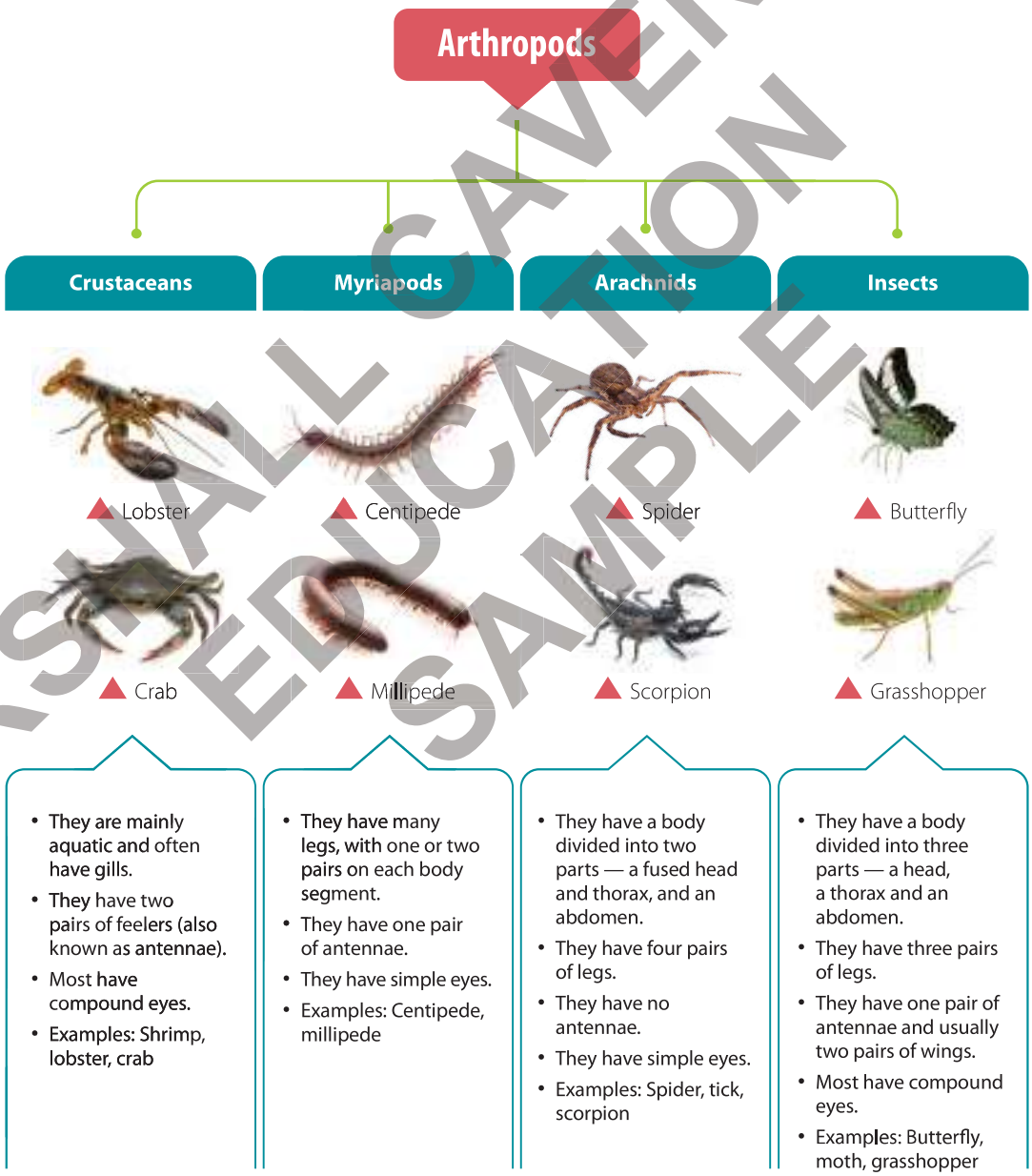


Figure 1.19 *Main groups of arthropods*

Vertebrates

Vertebrates are animals with a vertebral column (or a backbone). Fish, amphibians, reptiles, birds and mammals are five main groups or classes of vertebrates (Figure 1.20).

BIO WATCH

Scan this page to take a short quiz on characteristics and classification of living organisms.

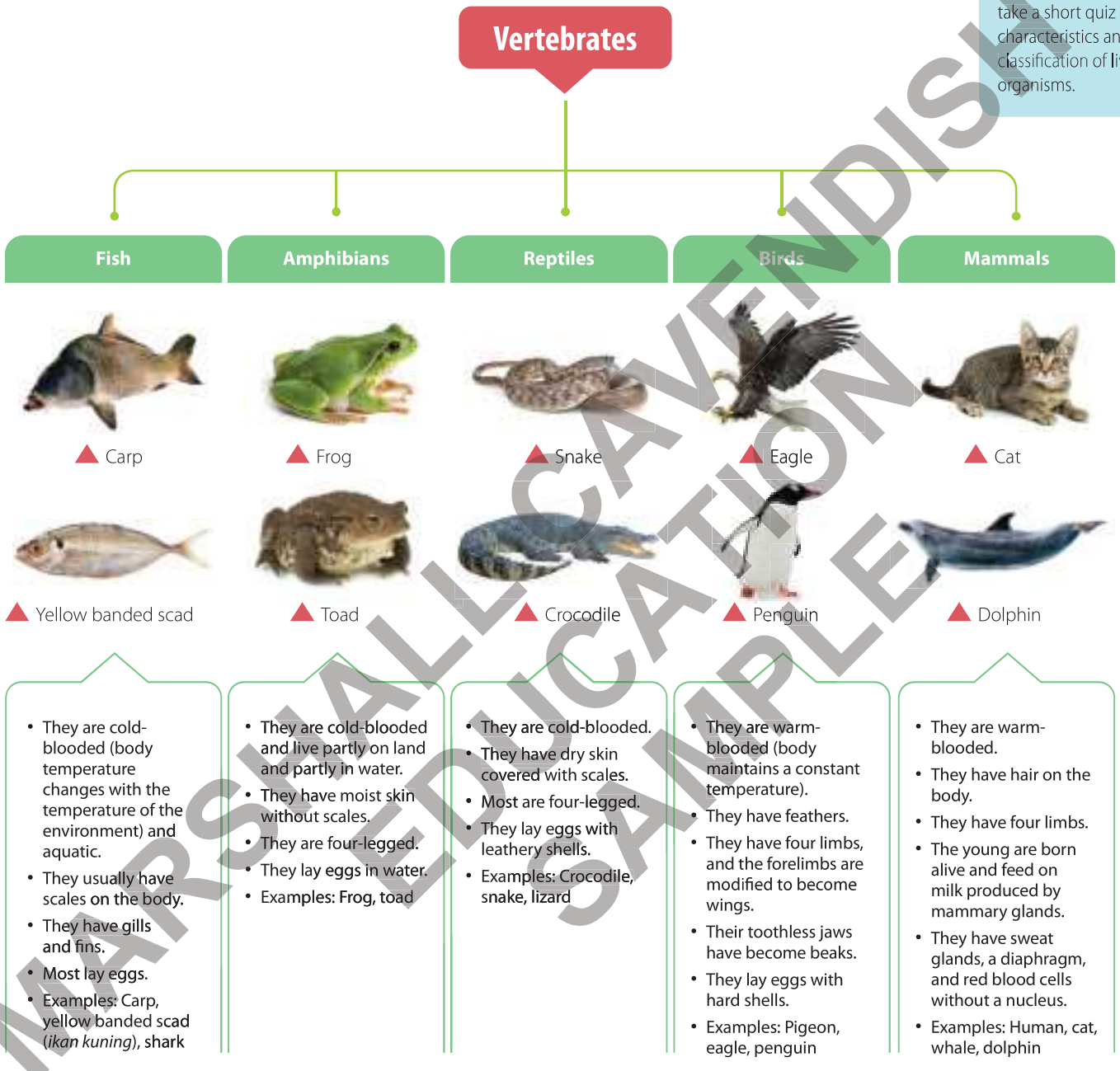


Figure 1.20 *Main groups of vertebrates*

How do we construct and use a dichotomous key to identify organisms?

A **dichotomous key** is used to identify and classify organisms. A dichotomous key has a series of paired statements called couplets. Each couplet consists of two contrasting statements. We work through the series of paired statements by choosing the one that matches the organism in each step, until the organism is identified.

Table 1.3 shows a dichotomous key used to identify the vertebrates in Figure 1.21.


Pigeon


Frog


Leopard cat


Water monitor


Tilapia


Goat

Figure 1.21 *Some vertebrates*

Table 1.3 *Dichotomous key to identify some vertebrates*

1	Scales present	Go to 2
	Scales absent	Go to 3
2	Fins present	Tilapia
	Fins absent	Water monitor
3	Moist skin	Frog
	Dry skin	Go to 4
4	Feathers present	Pigeon
	Feathers absent	Go to 5
5	Horns present	Goat
	Horns absent	Leopard cat

The dichotomous key can also be presented in a chart, as shown in Figure 1.22.

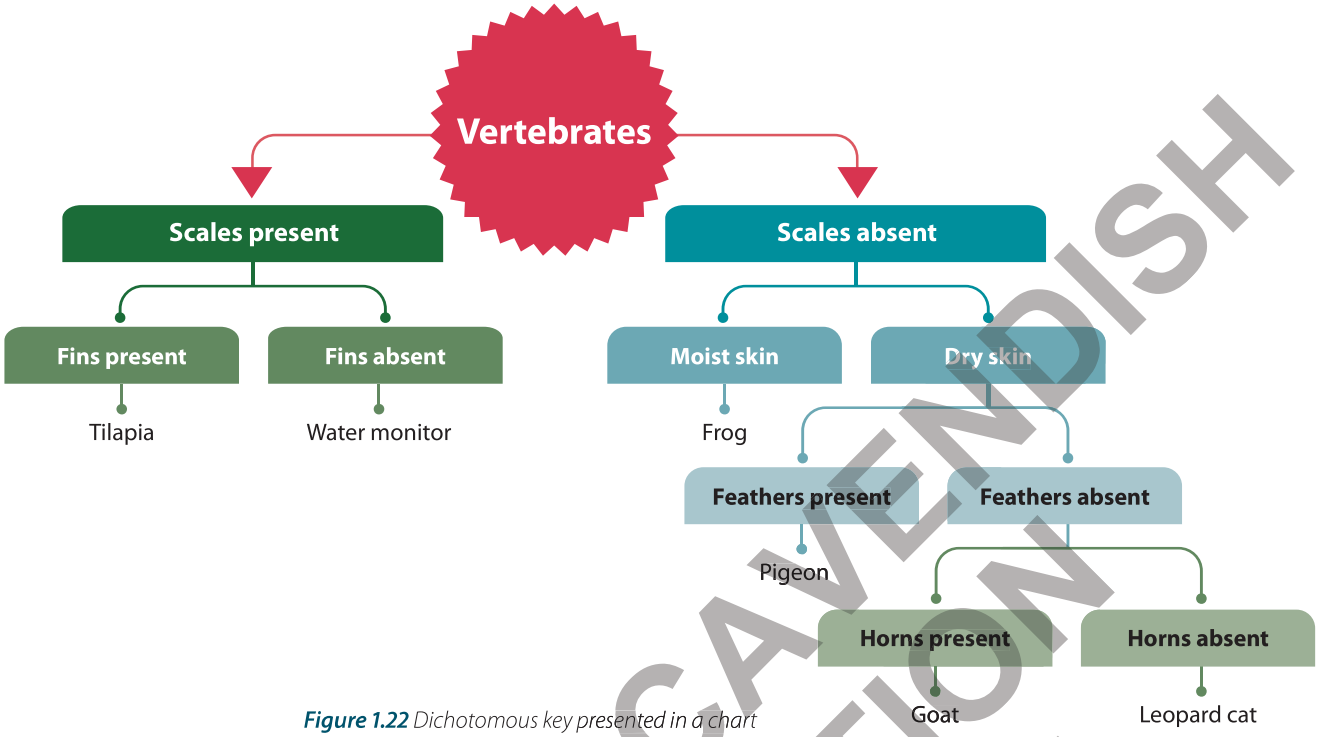


Figure 1.22 Dichotomous key presented in a chart

A dichotomous key can be constructed based on the observable features of organisms. You can follow these steps to construct a dichotomous key:

1 List the features of the organisms.
2 Choose a main feature not shared by all the organisms to divide them into two groups.
3 Choose another feature to further divide each group into two smaller groups. Continue to do this until you have identified all the organisms.

ENRICHMENT ACTIVITY

Choose organisms from different groups of arthropods and construct a dichotomous key to identify the organisms. Exchange your key with your classmates to check if it works.

Let's Practise 1.2

1 Table 1.4 shows the classification of the domestic cat.
The organisms in Figure 1.23 belong to the same family as the domestic cat. Classify each organism in a table as shown.

Table 1.4

Class	Mammalia
Order	Carnivora
Family	Felidae
Genus	*Felis*
Species	*domestica*


Panthera tigris


Panthera leo

Figure 1.23

2 The animal in Figure 1.24 is a wasp.
(a) Explain why the wasp is placed in the animal kingdom.
(b) The wasp is an arthropod. To which group of arthropods does the wasp belong? Give your reasons.


Figure 1.24

3 **Mind Map** Construct your own mind map for the concepts that you have learnt in this section.

LINK

Exercises 1B–1D

Let's Map It

LIVING ORGANISMS

share

can be grouped based on their shared features using

CHARACTERISTICS OF LIFE

- Made up of cells
- Nutrition
- Respiration
- Excretion
- Growth and development
- Movement
- Reproduction
- Sensitivity

CLASSIFICATION SYSTEMS

such as the

Biological system of classification

in which

Living organisms are classified into a hierarchy of groups, from the kingdom to the species.

where there are

Five kingdoms of living organisms

- S Prokaryote
- S Protoctista
- S Fungi
- Plantae
- Animalia

Some main groups within the animal kingdom

- Vertebrates
- Arthropods

Main groups of vertebrates

- Fish
- Amphibians
- Reptiles
- Birds
- Mammals

where a species is named using the

Binomial system of naming species

- The first name is the genus name.
- The second name is the species name.

S Some main groups within the plant kingdom

- Flowering plants
- Ferns

S Main groups of flowering plants

- Monocotyledons
- Dicotyledons

Main groups of arthropods

- Crustaceans
- Myriapods
- Arachnids
- Insects

Let's Review

Section A: Multiple-choice Questions

1 All living organisms are capable of _____.

A excretion and respiration
B locomotion and excretion
C photosynthesis and reproduction
D respiration and locomotion

2 Human beings are classified as *Homo sapiens*. Which group does each name refer to?

	Homo	*sapiens*
A	Family	Genus
B	Genus	Species
C	Order	Species
D	Species	Genus

3 Which of these describes the main difference between plants and animals?

A Animals can grow throughout their life but plants cannot.
B Animal cells have a large central vacuole but plant cells have many small vacuoles.
C Plants have cells with a nucleus but animals have cells without a nucleus.
D Plants make their own food but animals feed on other organisms to obtain nutrients.

Section B: Short-answer and Structured Questions

1 Study the list.

Feeding	Locomotion	Growth
Photosynthesis	Reproduction	Respiration

(a) Which of the characteristics are common to both plants and animals? [3]
(b) Which of the characteristics are common to animals **only**? [2]

2 S Study the features of the organisms in Figures 1.25 and 1.26.

Figure 1.25 *Organism X*

Figure 1.26 *Organism Y*

(a) State the kingdom to which both the organisms belong. [1]
(b) State the class to which each organism belongs. Give your reasons. [6]

3 Figure 1.27 shows some animals.

Figure 1.27

(a) Construct a dichotomous key to classify the animals. [5]
(b) Which **two** animals are more closely related to each other than to the rest? [2]

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