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Executive Preview

Biology

for Cambridge IGCSE™

MULTI-COMPONENT SAMPLE

Digital Access

Brighter Thinking
Better Learning

Dear Cambridge Teacher,

The new *Cambridge IGCSE™ Biology* series will publish in Spring 2021, updated for the revised Cambridge International syllabuses (0610/0970) for examination from 2023.

This Executive Preview contains sample content from the series, including:

- A guide explaining how to use the series
- A guide explaining how to use each resource
- The table of contents from each resource
- The first chapter from each resource, including the coursebook, workbook, practical workbook, teacher's resource including sample data and practical guidance, English language skills workbook and maths skills workbook

This new series has been designed after extensive research interviews and lesson observations with teachers and students around the world. As well as targeted support in the coursebook, we have produced updated workbooks to address the key challenges we heard from teachers. A new workbook includes exercises for each topic, providing more practice opportunities to consolidate students' learning. The practical workbook includes practical activities to develop students' investigative skills, with extensive support notes and exemplar data provided in the teacher's resource.

A maths skills workbook and an English skills workbook develop students' maths skills (in relation to science) and linguistic skills, in the context of the Cambridge IGCSE Biology syllabus respectively. Both resources publish in 2022.

We have also updated the teacher's resource. With teaching activity, assessment and homework ideas, guidance on how to tackle common misconceptions in each topic and a new feature developing your own teaching skills, we hope this resource will inspire and support you and save you time.

Finally, as we develop new resources, we ensure that we are keeping up to date with best practice in pedagogy. For this new series we have added features to the coursebook, such as engaging projects to develop students' collaborative skills and 'getting started' questions and activities to help you evaluate students' learning starting points. We have developed our differentiated support in this new series, with three-tier exercises in the workbook progressing from 'focus', to 'practice', to 'challenge' and differentiated worksheets for each of the syllabus topics in the teacher's resource, supporting all your learners' different needs.

Visit our website to view the full series or speak to your local sales representative.

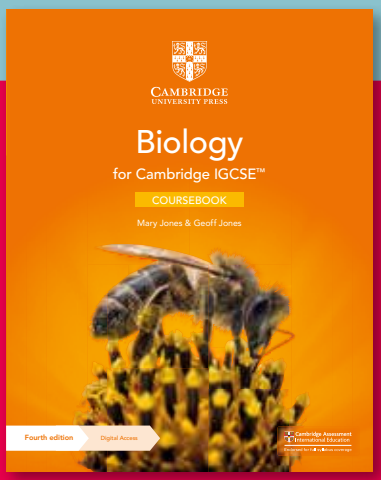
cambridge.org/education

Priyanka Comar and Gemma Coleman

Commissioning Editors for Cambridge IGCSE™ Sciences, Cambridge University Press

How to use this series

This suite of resources supports learners and teachers following the Cambridge IGCSE™ Biology syllabus. All of the books in the series work together to help students develop the knowledge and scientific skills required for this subject. We offer a comprehensive, flexible array of resources providing targeted support and practice for the specific challenges that science teachers have told us they face: students learning science in English as a second language; learners who find the mathematical content within science to cause difficulty; and developing essential practical skills.

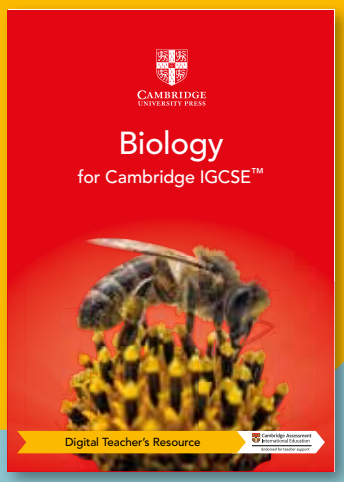


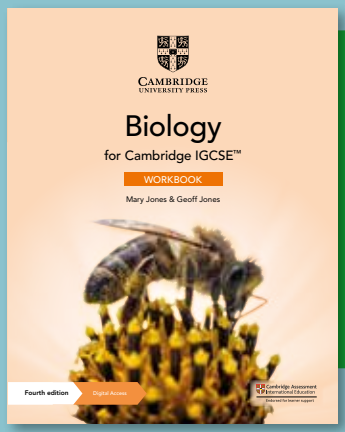
The coursebook provides comprehensive coverage of the full Cambridge IGCSE Biology syllabus. Each chapter clearly explains facts and concepts, and uses relevant real-world examples of scientific principles to bring the subject to life. Together with a focus on practical work and plenty of active learning opportunities, the coursebook prepares learners for all aspects of their scientific study. Questions within every chapter help learners to consolidate their knowledge and understanding. At the end of each chapter, examination-style questions offer practice opportunities for learners to apply their learning.

The teacher's resource contains detailed guidance for all topics of the syllabus, including background knowledge to identify learners' prior knowledge, and common misconceptions identifying areas where learners might need extra support, as well as an engaging bank of lesson ideas for each syllabus topic. Differentiation is emphasised with advice for identification of different learner needs and suggestions of appropriate interventions to support and stretch learners. The teacher's resource also contains support for preparing and carrying out all the investigations in the practical workbook, including tips for getting things to work well, and a set of sample results for the times when practicals aren't possible.

Teachers are supported and empowered to develop their teaching skills with the Teaching Skills Focus feature, which embeds pedagogical approaches within the context of each chapter.

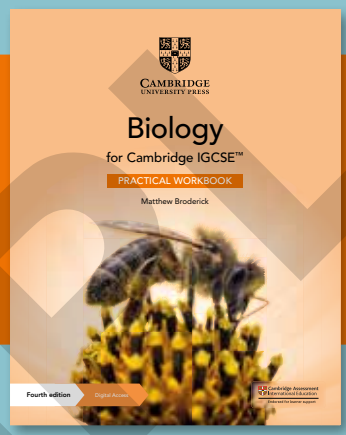
The teacher's resource also contains scaffolded worksheets and unit tests for each chapter, as well as answers to all questions in the coursebook, workbook, practical workbook, maths skills workbook and English language skills workbook.





The skills-focused write-in workbook has been carefully constructed to help learners develop the skills that they need as they progress through their Cambridge IGCSE Biology course, providing further practice of all the topics in the coursebook and helpful tips to address common misconceptions. A three-tier, scaffolded approach to skills development enables students to gradually progress through 'focus', 'practice' and 'challenge' exercises, ensuring that every learner is supported. The workbook enables independent learning and is ideal for use in class or as homework.

This write-in book provides learners with additional opportunities for hands-on practical work, giving them full guidance and support that will help them to develop all of the essential investigative skills. These skills include planning investigations, selecting and handling apparatus, creating hypotheses, recording and displaying results, and analysing and evaluating data.



Mathematics is an integral part of scientific study, and one that learners often find a barrier to progression in science. Learners can find it difficult to apply maths knowledge to science scenarios, even if they have encountered the maths concept previously. The Maths Skills for Cambridge IGCSE Biology write-in workbook has been written in collaboration with the Association of Science Education, with each chapter focusing on several maths skills that their research concluded that students need to succeed in their Biology course.

Our research shows that English language skills are the single biggest barrier to students accessing international science. This write-in workbook contains exercises set within the context of IGCSE Biology topics to consolidate understanding and embed practice in aspects of language central to the subject. Activities range from practising using 'effect' and 'affect' in the context of enzymes, to writing about expiration with a focus on common prefixes.

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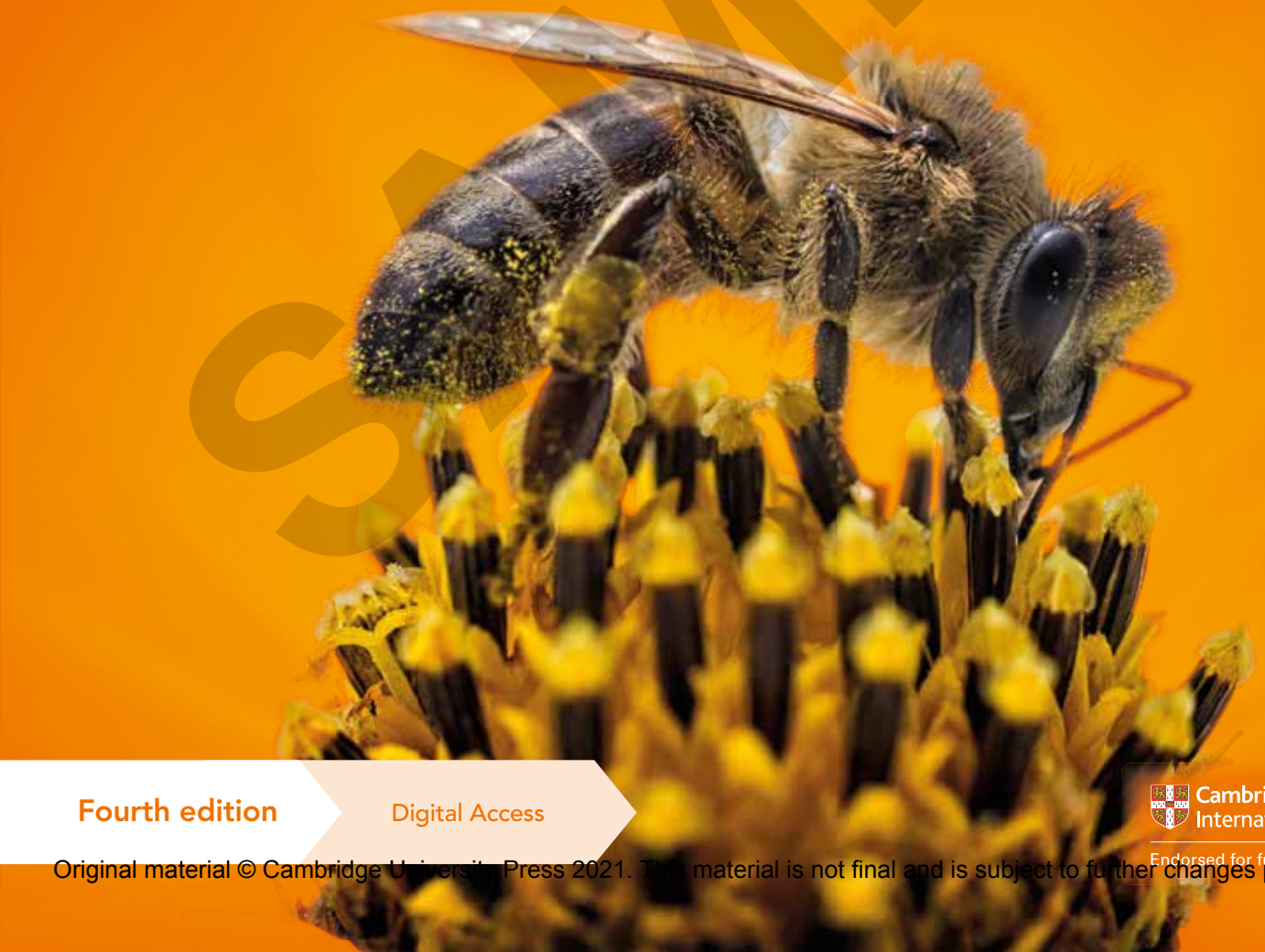
Biology

for Cambridge IGCSE™

COURSEBOOK

Mary Jones & Geoff Jones



Fourth edition

Digital Access

Cambridge Assessment International Education

Endorsed for full syllabus coverage

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How to use this book

Throughout this book, you will notice lots of different features that will help your learning. These are explained below.

LEARNING INTENTIONS

These set the scene for each chapter, help with navigation through the coursebook and indicate the important concepts in each topic.

In the learning intentions table, the summary table and the exam-style questions, Supplement content is indicated with a large arrow and a darker background, as in the example here.

GETTING STARTED

This contains questions and activities on subject knowledge you will need before starting this chapter.

SCIENCE IN CONTEXT

This feature presents real-world examples and applications of the content in a chapter, focussing on topics that go beyond the syllabus. There are discussion questions at the end, which look at some of the benefits and problems of these applications, and encourage you to look further into the topics.

EXPERIMENTAL SKILLS

This feature focuses on developing your practical skills. They include lists of equipment required and any safety issues, step-by-step instructions so you can carry out the experiment, and questions to help you think about what you have learnt.

KEY WORDS

Key vocabulary is highlighted in the text when it is first introduced, and definitions are given in boxes near the vocabulary. You will also find definitions of these words in the Glossary at the back of this book.

Questions

Appearing throughout the text, questions give you a chance to check that you have understood the topic you have just read about. The answers to these questions are accessible to teachers for free on the Cambridge GO site.

ACTIVITY

Activities give you an opportunity to check and develop your understanding throughout the text in a more active way, for example by creating presentations, posters or role plays. When activities have answers, teachers can find these for free on the Cambridge GO site.

COMMAND WORDS

Command words that appear in the syllabus and might be used in exams are highlighted in the exam-style questions. In the margin, you will find the Cambridge International definition. You will also find these definitions in the Glossary at the back of the book with some further explanation on the meaning of these words.

Supplement content: Where content is intended for students who are studying the Supplement content of the syllabus as well as the Core, this is indicated using the arrow and the bar, as on the left here. You may also see the teal text with just an arrow (and no bar), in boxed features such as the Key Words or the Getting Started.

REFLECTION

These activities ask you to think about the approach that you take to your work, and how you might improve this in the future.

SELF/PEER ASSESSMENT

At the end of some activities and experimental skills boxes, you will find opportunities to help you assess your own work, or that of your classmates, and consider how you can improve the way you learn.

These boxes tell you where information in the book is extension content, and is not part of the syllabus.

SUMMARY

There is a summary of key points at the end of each chapter.

PROJECT

Projects allow you to apply your learning from the whole chapter to group activities such as making posters or presentations, or taking part in debates. They may give you the opportunity to extend your learning beyond the syllabus if you want to.

EXAM-STYLE QUESTIONS

Questions at the end of each chapter provide more demanding exam-style questions, some of which may require use of knowledge from previous chapters. The answers to these questions are accessible to teachers for free on the Cambridge GO site.

SELF-EVALUATION CHECKLIST

The summary checklists are followed by 'I can' statements which relate to the Learning intentions at the beginning of the chapter. You might find it helpful to rate how confident you are for each of these statements when you are revising. You should revisit any topics that you rated 'Needs more work' or 'Almost there'.

I can	See Topic...	Needs more work	Almost there	Confident to move on
Core				
Supplement				

Chapter 1

Characteristics & classification of living organisms

IN THIS CHAPTER YOU WILL:

- learn about the seven characteristics of living organisms
- find out how the binomial system is used to name organisms
- practise using and constructing keys
- describe how to classify vertebrates and arthropods

- describe the features of the five kingdoms of organisms
- describe how to classify ferns and flowering plants
- outline the features of viruses.

GETTING STARTED

1 The list below contains some features of living organisms. With your partner, discuss which of these features are found in *all* living organisms.

breathing **excretion** **a blood system** **a nervous system** **sensitivity**

growth **reproduction** **movement** **nutrition** **respiration**

2 When you have made your decisions, write a very short description of each of the features you have chosen.

Be ready to share your ideas.

THE PUZZLE OF THE PLATYPUS

In 1799, a dead specimen of a strange animal was taken to England from Australia. The animal had a beak and webbed feet, like a duck. It had fur, like a mole. No one knew whether it laid eggs or gave birth to live young. So, was it a bird? Was it a mammal? No one could decide.

It was studied by Dr George Shaw. To begin with, he thought it was a hoax. He looked to see if the beak was stitched onto the head, but no – the beak was clearly a genuine part of the animal.

Dr Shaw gave the animal a Latin name, *Platypus anatinus*. 'Platypus' means 'flat-footed' and 'anatinus' means 'like a duck'. However, someone then pointed out that the name *Platypus* had already been taken and belonged to a species of beetle. So, another name was suggested – *Ornithorhynchus paradoxus*. The first word means 'nose like a bird' and the second means 'puzzling'. The name has now changed back again, to *Platypus anatinus*.

Later, proof was found that platypuses lay eggs, rather than giving birth to live young. However, they feed their young on milk, which is a characteristic feature of mammals. Scientists eventually decided to classify the platypus as a mammal. It was put into a new group of mammals, called monotremes, which also includes the echidnas (spiny anteaters).

Figure 1.1: A platypus is adapted for hunting prey under water.

Discussion questions

1 Scientists give every species on Earth a two-word name that is used by everyone, all over the world. Do you think this is a good idea? Why do you think this?

2 Scientific names for organisms are in Latin, which is a language that no one speaks now. This naming system was invented in the 18th century. Do you think using Latin is a good idea?

1.1 Characteristics of organisms

Biology is the study of organisms. An **organism** is a complete living thing – such as yourself, a platypus, a bacterium or a mango tree. There are very many different kinds of organism on Earth, but all of them share seven characteristics (Figure 1.2). Some non-living things have some of these characteristics, but no non-living thing has all of them.

KEY WORDS

organism: a living thing

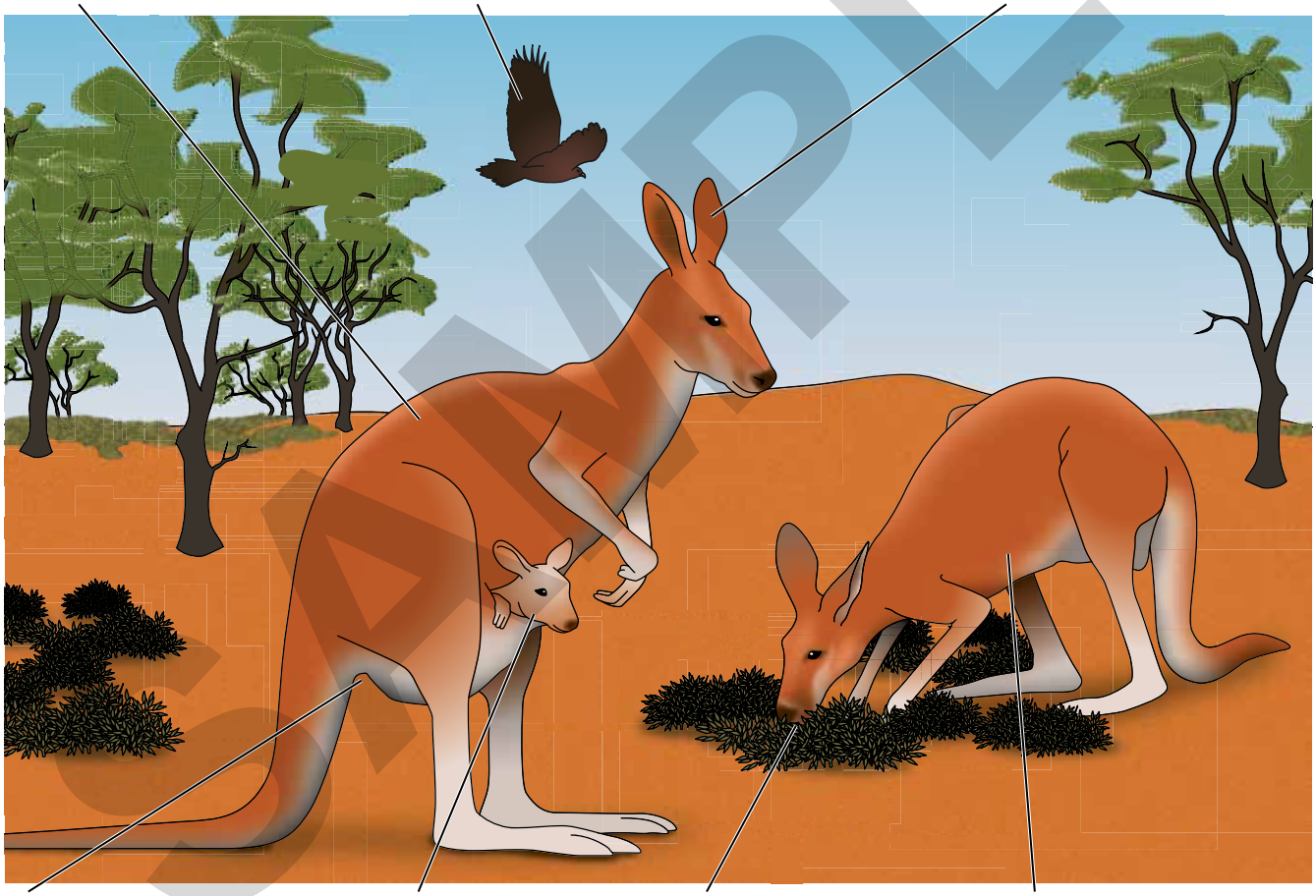
movement: an action by an organism or part of an organism causing a change of position or place

Movement is the ability of an organism, or part of it, to change position or place. It is easy to see most animals moving, but less easy to see a plant move.

Growth All organisms begin small and get larger, by the growth of their cells and by adding new cells to their bodies.

Movement All organisms are able to move to some extent. Most animals can move their whole body from place to place, and plants can slowly move parts of themselves.

Sensitivity All organisms pick up information about changes in their environment, and react to the changes.



Excretion All organisms produce unwanted or toxic waste products as a result of their metabolic reactions, and these must be removed from the body.

Reproduction Organisms are able to make new organisms of the same species as themselves.

Nutrition Organisms take substances from their environment and use them to provide energy or materials to make new cells.

Respiration All organisms break down glucose and other substances inside their cells, to release energy that they can use.

Figure 1.2: Characteristics of living organisms.

Figure 1.3: This fly is about to be caught in a trap. The Venus flytrap leaves will close together, trapping the fly inside. The plant will digest the fly and absorb nutrients from it.

Figure 1.4: When a pufferfish detects a threat, it swallows water and inflates (puffs up) its spiny body so that predators cannot easily eat it.

A few plants can move parts of themselves quite quickly (Figure 1.3). And in almost any plant, if you look at the cells under the microscope, you can see chloroplasts moving about inside them.

Respiration is the way that organisms obtain energy from nutrients – usually from glucose. Respiration is a chemical reaction that happens inside every living cell. You will find out much more about respiration in Chapter 11. Organisms use the energy that they obtain from respiration to make other chemical reactions in their cells happen. All of these chemical reactions – including respiration – are called **metabolism**.

KEY WORDS

respiration: the chemical reactions in cells that break down nutrient molecules and release energy for metabolism

metabolism: the chemical reactions that take place in living organisms

sensitivity: the ability to detect and respond to changes in the internal or external environment

growth: a permanent increase in size and dry mass

dry mass: the mass of an organism after it has been killed and all water removed from it

reproduction: the processes that make more of the same kind of organism

Sensitivity is the ability to detect changes in the environment and respond to them. These changes may be in the internal environment (such as the temperature of the blood) or the external environment (such as the intensity of sunlight). For example, you use your ears to detect someone talking to you. Plants detect the direction that light is coming from and can turn their flowers to face the sun.

Growth can be defined as a permanent increase in size and dry mass. All organisms can grow. Some organisms – such as a pufferfish – can get bigger just for a short time to help to deter (put off) predators (Figure 1.4). This is not growth, because the fish goes back to its original size when the threat has gone away. Plants and animals grow by producing new cells. If you are studying the Supplement, you will find out how they do this in Chapter 16.

We can measure growth in many ways. One method is to find the **dry mass**. This involves finding the mass of several organisms of the same type over a period of time. An organism is killed and dried (so this method is more often used for plants than for animals). The mass of its body without any water is then found. After a particular period of time – for example, one day – the dry mass of another of the organisms is found. This is repeated with several organisms for the growth period being observed.

Reproduction means making more organisms of the same kind. Not every individual organism can reproduce, but at least some individuals of each kind of organism can do so. You can find out more about reproduction in Chapters 14 and 15.

There are many different chemical reactions going on inside every living cell. Some of the products that are formed in these reactions are not needed by the cells. These waste products are removed from the organism, in a process called **excretion**. Excretion also removes substances in excess of requirements – for example, extra water. You can find out about excretion in humans in Chapter 13.

Nutrition is the last of the seven characteristics of all organisms. All living organisms need chemicals to build their cells, and also as a source of energy. Nutrition means taking in materials that provide these things. Plants and animals have very different methods of nutrition, and you will find out about this in Chapters 6 and 7.

ACTIVITY 1.1

Matching the characteristics of living things with their descriptions

Work in a group of four or five for this activity.

You will need:

- 14 pieces of blank card, all exactly the same.

1. Write the seven characteristics of living things on seven of the pieces of card.
2. Write descriptions of each of the seven characteristics on the other seven cards.
3. Shuffle each set of cards. Place them face down in two rows of seven.
4. One person then selects a card from each row and turns them face up. If the name and description match, this person keeps the two cards. If they do not match, they place them face down again in the same positions.
5. Now the next person does the same.
6. Keep taking turns until all the cards have been taken by someone. The winner is the person with most cards at the end.

KEY WORDS

excretion: the removal of the waste products of metabolism and substances in excess of requirements

nutrition: taking in materials for energy, growth and development

1.2 The biological classification system

Classification means putting things into groups. There are many possible ways that we could classify organisms. For example, we could put all the animals with legs into one group, and all the other organisms into different groups. But this would mean that insects went into the same group as vertebrates. This would not make much sense, because we can easily see that insects and vertebrates are very different kinds of animal (Figure 1.5).

Biologists try to classify organisms according to how closely they think they are related. Long ago – perhaps 4.5 billion years ago – the first living organism appeared on Earth. It would have been a single cell. Since then, over a very long period of time, this cell gave rise to more complex organisms. For example, we think that all mammals descended from a species that lived more than 200 million years ago. This species was the **common ancestor** of mammals. All mammals are related because they all share a relatively recent common ancestor.

KEY WORDS

common ancestor: a species that lived in the past, and is thought to have given rise to several different species alive today; for example, all mammals share a common ancestor

When we classify organisms, we look for features that they share with others, which suggest that they are related to one another. This is a useful way of classifying things, because it helps us to understand how an organism 'works'. If we find a new animal that has hair and feeds its young on milk, we know that it is a mammal. We already know a lot about it, even before we can study it in detail.

Figure 1.5: Although they both have legs these two animals are not closely related. The ant is an insect, so it belongs to the arthropod group. The chameleon is a reptile, and belongs to the vertebrate group.

Species

The smallest group into which biologists classify living organisms is the **species**. (Species is an unusual word, because the singular and plural are exactly the same – one species and many species.) A species is a group of organisms that can reproduce with each other to produce offspring that can also reproduce. The offspring are **fertile**.

For example, horses belong to the species *Equus caballus*. Members of this species can reproduce with each other. The offspring are also horses. They belong to the same species, and they can reproduce again to produce more horses.

Donkeys belong to a different species, *Equus asinus*. Donkeys reproduce with each other to produce fertile donkeys. But donkeys can also reproduce with horses. If a male donkey reproduces with a female horse, the offspring is a mule. Mules 'work' very well – they are usually strong, healthy organisms (Figure 1.6), but they cannot reproduce. They are **infertile**.

KEY WORDS

species: a group of organisms that can reproduce to produce fertile offspring

fertile: able to reproduce

infertile: not able to reproduce

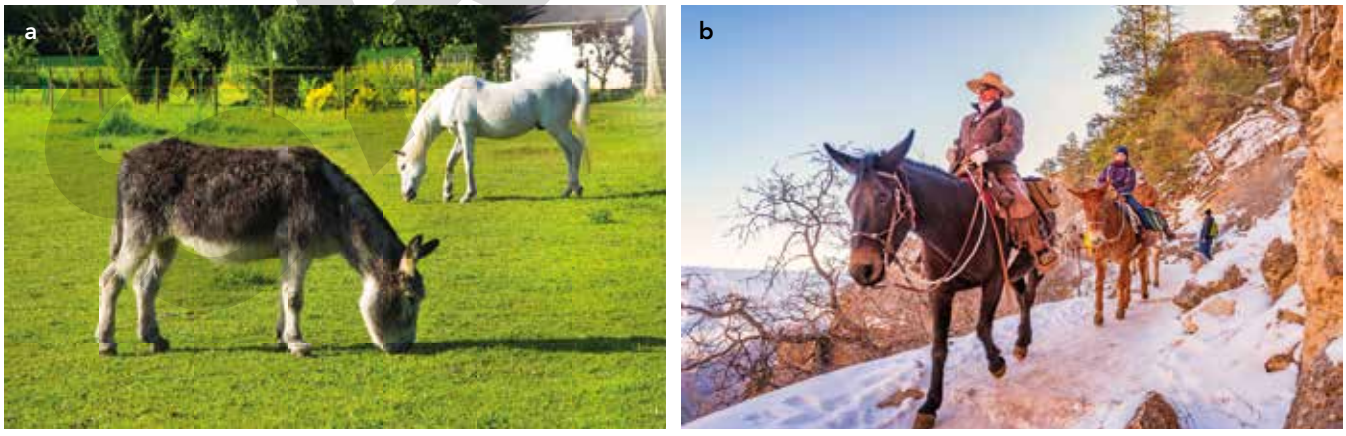


Figure 1.6 a: Horses and donkeys belong to different species. **b:** Mules are the result of reproduction between horses and donkeys. They are infertile.

The binomial naming system

You have seen that the 'official' names for the species that horses and donkeys belong to are written in a special way. This is the way that biologists name each species on Earth.

These scientific names always have two words. The naming system is therefore called the **binomial system**. 'Bi' means two, and 'nomial' means to do with names.

The first name in the binomial is the name of the **genus** that the organism belongs to. A genus is a group of species that are related to one another. If you look at Figure 1.6, you can see that horses and donkeys share a lot of features. They are obviously different species, but they belong to the same genus.

In the two-word name, the genus is always written with a capital letter. The second name tells us which species the organism belongs to, and this is written with a small letter. When the binomial is printed, it is in italics. You cannot do that when you are writing, but instead you can underline the binomial.

Questions

1 Yaks have the scientific name *Bos grunniens*. Explain what this tells us about the groups into which yaks are classified.

2 A yakolo is the offspring of a yak and a buffalo. Yakolos are unable to reproduce.

Explain how this suggests that yaks and buffalo belong to different species.

1.3 Keys

If you want to identify an organism whose name you do not know, you may be able to find a picture of it in a book. However, not every organism may be pictured, or your organism may not look exactly like any of the pictures. If this happens, you can use a **dichotomous key** to work out what your organism is.

'Dichotomous' means branching (dividing) into two. A dichotomous key is a way of leading you through to the name of your organism by giving you two descriptions at a time and asking you to choose between them. Each choice you make then leads you on to another pair of descriptions, until you end up with the name of your organism. Here is a key that you could use to identify the organisms shown in Figure 1.7.

1	jointed limbs	2
	no jointed limbs	earthworm
2	more than 5 pairs of jointed limbs	centipede
	5 or fewer pairs of jointed limbs	3
3	first pair of limbs form large claws	crab
	no large claws	4
4	3 pairs of limbs	locust
	4 pairs of limbs	spider

KEY WORDS

binomial system: a system of naming species that is internationally agreed, in which the scientific name is made up of two parts showing the genus and the species

genus: a group of species that share similar features and a common ancestor

dichotomous key: a way of identifying an organism, by working through pairs of statements that lead you to its name

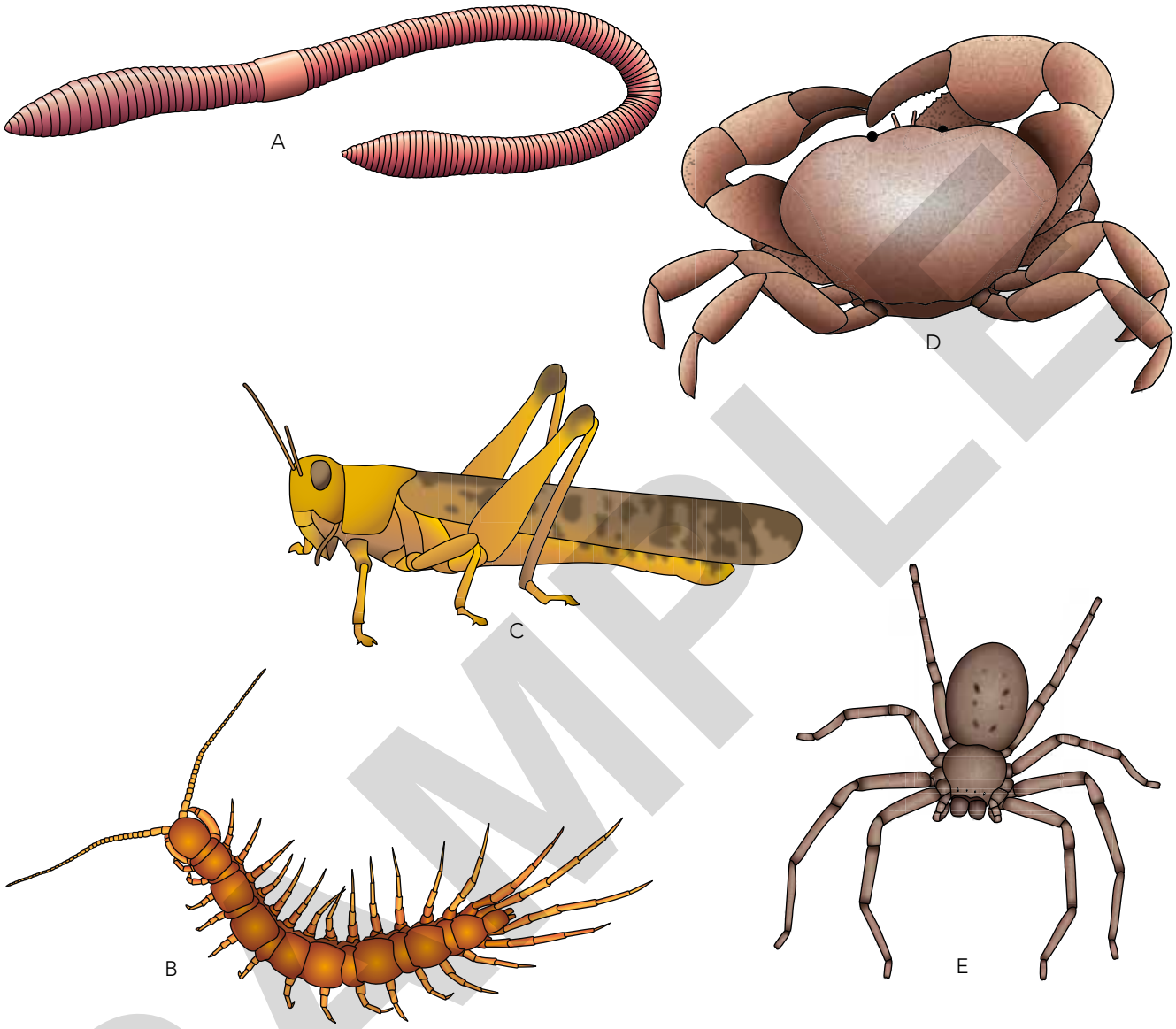


Figure 1.7: Five organisms for practising using a key.

To use the key:

- Choose **one** of the animals that you are going to identify. Let's say you choose organism B.
- Look at the first pair of statements in the key. Decide which description in step 1 matches your organism. It has jointed limbs, so the key tells us to go to step 2.
- Look at the descriptions in step 2. Decide which describes organism B. It has more than 5 pairs of jointed limbs, so it is a centipede.

Now try working through the key to identify the other four animals.

Notice that, in the key, each pair of statements are 'opposites' of one another. In 1, for example, the two statements are about whether the organism has jointed limbs or not. Remember this when you are writing your own keys. Don't mix different ideas into a pair of statements.

ACTIVITY 1.2

Constructing a key

Using a key is quite easy, but writing your own key is much more of a challenge.

Work with a partner for this activity.

You are going to write a key to enable someone to identify each of the four flowers in Figure 1.8.

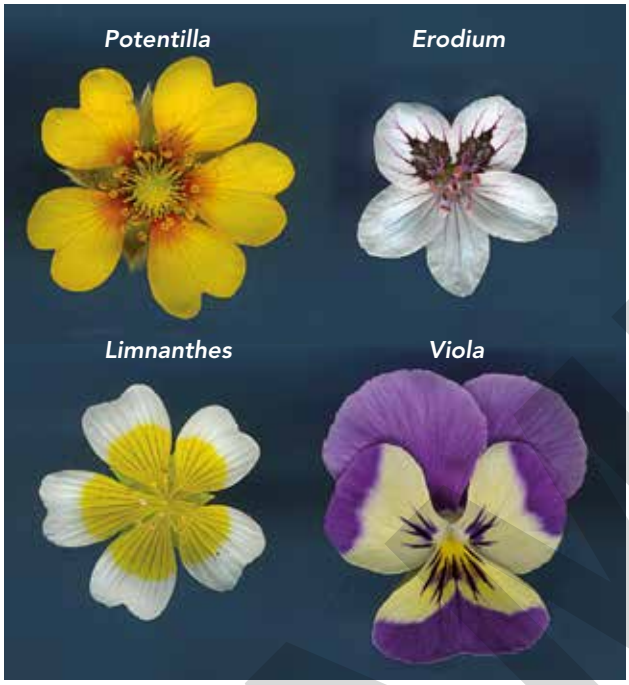


Figure 1.8: Four flowers for identification using a key.

First, make a list of features that clearly differ between the flowers. They should be features that cannot possibly be mistaken. Remember that the person using the key will probably only have one of the flowers to look at, so they cannot necessarily compare it with another kind of flower. Therefore, the number of petals or the colour is a good choice, but the size (large or small) is not, because different people might have different ideas about what is 'large' or 'small'.

Choose one of the features that can split the flowers into two groups. The two groups don't have to be the same size – you could have two in one group and two in the other, or perhaps one in one group and the other three flowers in the second group.

Write down the two statements for this feature. Remember that the two statements need to be 'opposites' of one another.

Next, concentrate on a group that contains more than one flower. Choose another feature that will allow you to split the flowers into two further groups. Keep doing this until each 'group' contains only one flower.

Go back to your key and make changes to improve it. Think carefully about the wording of each pair of statements. Make sure that each pair is made up of two clear alternatives. Try to reduce your key to the smallest possible number of statement pairs.

Finally, try your key out on a friend. If they have any problems with it, then try to reword or restructure your key to make it easier to use.

Self-assessment

Rate yourself according to the following scheme for each of the points listed.

☺ if you did it really well
😐 if you made a good attempt at it and partly succeeded
☹ if you did not try to do it, or did not succeed

- I had my own ideas, but I also listened to my partner's ideas.
- We wrote the descriptions in the key very clearly.
- We chose descriptions that other people could easily use.
- The two statements in each pair were 'opposites' of one another.
- Our key had no more than three pairs of statements.
- When we asked other people to try our key, they found it easy to use.

REFLECTION

Describe one thing that you think you did very well when you worked on constructing your key.

Now describe one thing that you will try to do better, next time you construct a key.

1.4 Kingdoms

We have seen that the species is the smallest group into which living organisms are classified. Now we will look at the largest groups. These are the **kingdoms** of living organisms.

The kingdoms with which we are most familiar are the animal kingdom and the plant kingdom.

The animal kingdom

Animals (Figure 1.9) are usually easy to recognise. Most animals can move actively, looking for food. Under the microscope, we can see that their cells have no cell walls.

Figure 1.9: Jellyfish, birds and butterflies all belong to the animal kingdom.

Characteristic features of animals:

- Their cells have a nucleus, but no cell walls or chloroplasts.
- They feed on **organic substances** made by other living organisms.

The plant kingdom

The plants that are most familiar to us are the flowering plants, which include most kinds of trees. These plants have leaves, stems, roots and flowers (Figures 1.10 and 1.11). However, there are other types of plants – including ferns and mosses – that do not have flowers. What all of them have in common is the green colour, caused by a pigment called **chlorophyll**. This pigment absorbs energy from sunlight, and the plant can use this energy to make sugars, by the process of photosynthesis.

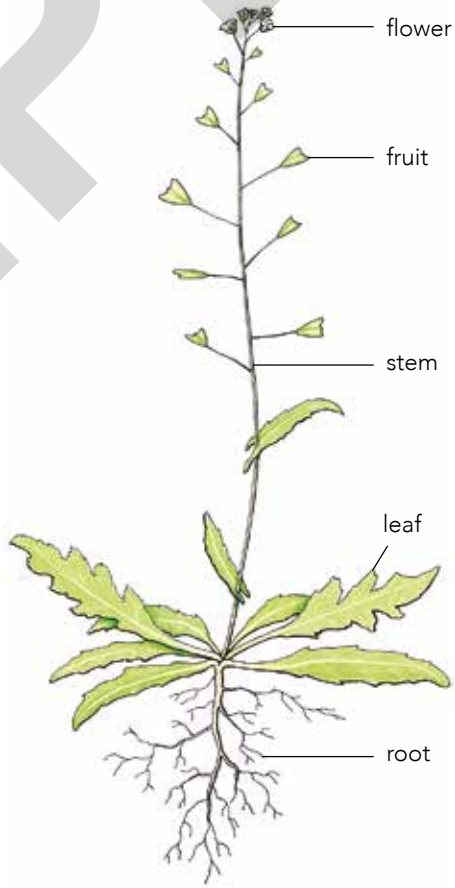


Figure 1.10: Many kinds of plant have roots, stems and leaves. Some also have flowers.

Figure 1.11: Moss, saguaro cacti and coconut palms belong to the plant kingdom.

Because they do not need to move around to get their food, plants are adapted to remain in one place. They often have a spreading shape, enabling them to capture as much sunlight energy as possible. Under the microscope we can see that the cells of plants have cell walls.

Characteristic features of plants:

- Their cells have a nucleus and cell walls made of **cellulose** and often contain chloroplasts.
- They feed by photosynthesis.
- They may have roots, stems and leaves (but some plants do not have these organs).

KEY WORDS

kingdom: one of the major groups into which all organisms are classified

organic substances: substances whose molecules contain carbon; in biology, we normally consider organic compounds to be ones that are made by living things

chlorophyll: a green pigment (coloured substance) that absorbs energy from light; the energy is used to combine carbon dioxide with water and make glucose

cellulose: a carbohydrate that forms long fibres, and makes up the cell walls of plants

Questions

3 Figure 1.12 shows a sea anemone, which belongs to the animal kingdom.

Figure 1.12: A sea anemone.

a In the past, people used to think that sea anemones were plants. Suggest why.

b Explain how using a microscope could help you to confirm that sea anemones are animals.

4 Figure 1.13 shows part of a plant called a liverwort. Liverworts do not have roots or flowers. Suggest how you could show that a liverwort belongs to the plant kingdom.

Figure 1.13: Part of a liverwort.

The five kingdoms

As well as the animal kingdom and the plant kingdom, there are three other kingdoms into which organisms are classified. These are the **fungus**, **prokaryote** and **protoctist** kingdoms.

The fungus kingdom

For a very long time, fungi were classified as plants. However, we now know that they are really very different, and belong in their own kingdom. Figure 1.14 shows some of the features of fungi.

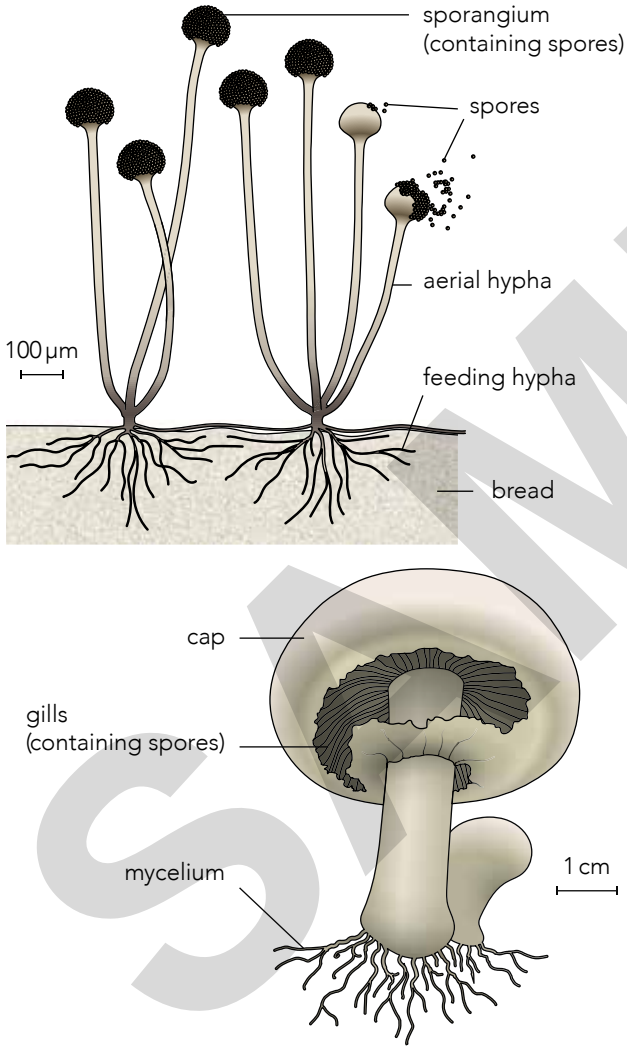


Figure 1.14: Two examples of fungi.

KEY WORDS

fungus: an organism whose cells have cell walls, but that does not photosynthesise

prokaryote: an organism whose cells do not have a nucleus

protoctist: a single-celled organism, or one with several very similar cells

hyphae: microscopic threads, made of cells linked in a long line, that make up the body of a fungus

Mushrooms and toadstools are fungi, and they can be colourful and easy to spot (Figure 1.15). However, the main body of most fungi, including mushrooms and toadstools, is made up of microscopic threads called **hyphae**. These are made of many cells joined end to end. The cells have cell walls, but these are not made of cellulose.

Figure 1.15 a: These toadstools are feeding on dead wood. Their hyphae grow through the wood, taking up nutrients from it. **b:** The mould on this strawberry is a fungus.

Fungi do not have chlorophyll and do not photosynthesise. Instead they feed saprophytically, or parasitically, on organic material such as faeces, human foods and dead plants or animals. Many fungi are **decomposers**, breaking down waste material from other organisms and dead organisms. This helps to return nutrients to the soil that other organisms can use for their growth.

Fungi reproduce by forming **spores**. These are tiny groups of cells with a tough, protective outer covering. They can be spread by the wind or animals, and grow to form a new fungus.

We have found many different uses to make of fungi. We eat them as mushrooms. We use the single-celled fungus, yeast, to make ethanol and bread – you can find out about this in Chapter 20. We obtain antibiotics such as penicillin from various different fungi.

Some fungi, however, are harmful. Some of these cause food decay, while a few cause diseases, including ringworm and athlete's foot.

Characteristic features of fungi:

- They are usually **multicellular** (many-celled), but some such as yeast are **unicellular** (single-celled).
- They have nuclei and cell walls, but the walls are not made of cellulose.
- They do not have chlorophyll.
- They feed by digesting waste organic material and absorbing it into their cells.

KEY WORDS

decomposers: organisms that break down organic substances outside their bodies, releasing nutrients from them that other organisms can use

spores: very small groups of cells surrounded by a protective wall, used in reproduction

multicellular: made of many cells

unicellular: made of a single cell

The protoctist kingdom

The kingdom Protoctista (Figures 1.16 and 1.17) contains a mixed collection of organisms. They all have cells with a nucleus, but some have plant-like cells with chloroplasts and cellulose cell walls, while others have animal-like cells without these features. Most protoctists are unicellular (made of just a single cell) but some, such as seaweeds, are multicellular.

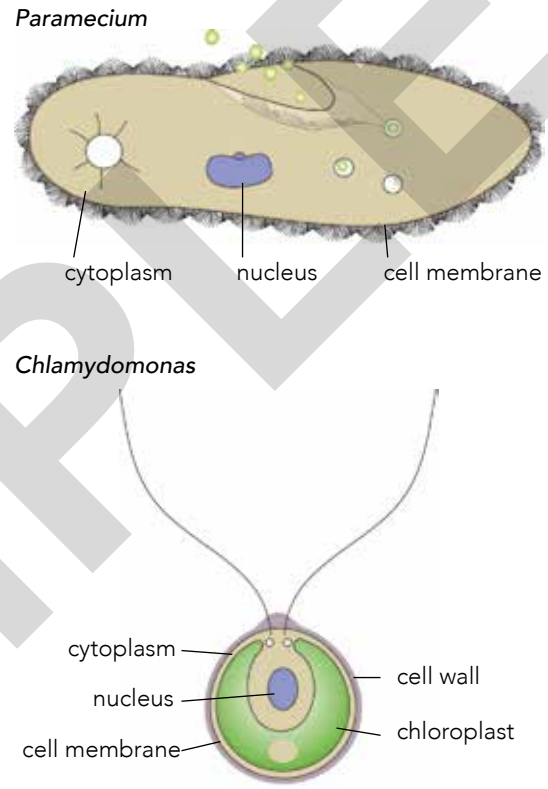


Figure 1.16: Two examples of protoctists. *Paramecium* has animal-like cells, while *Chlamydomonas* has plant-like cells.

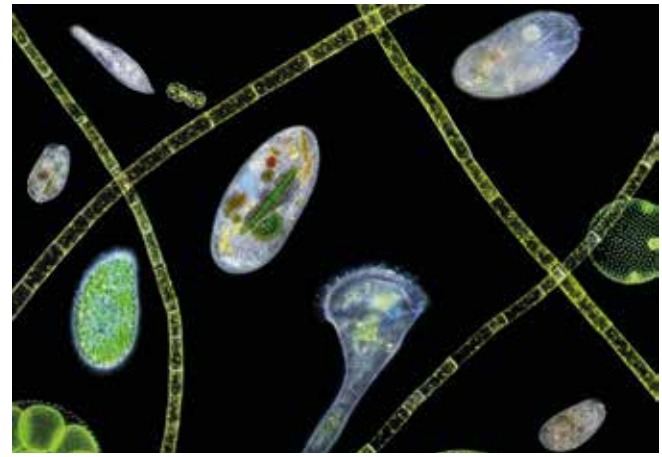


Figure 1.17: This photograph shows some pond water seen through a microscope. All of the organisms are protoctists. Some are unicellular, and some are multicellular. Some have cells like animal cells, while others have cells like plant cells.

Characteristic features of protoctists:

- They are multicellular or unicellular.
- Their cells have a nucleus and may or may not have a cell wall and chloroplasts.
- Some feed by photosynthesis and others feed on organic substances made by other organisms.

The prokaryote kingdom

The prokaryote kingdom contains a huge number of organisms, but we are often completely unaware of them. Bacteria (Figures 1.18 and 1.19) belong to this kingdom. Bacteria have cells that are very different from the cells of organisms in the other four kingdoms. The most important difference is that they do not have a nucleus.

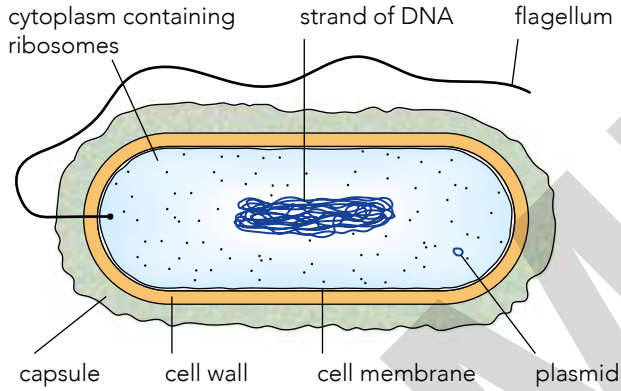


Figure 1.18: The structure of a prokaryotic cell.

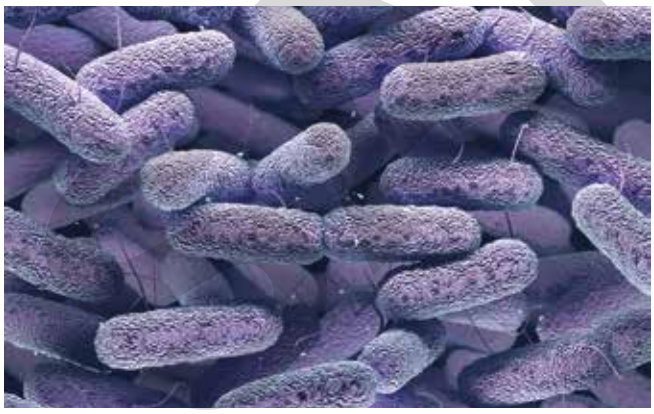


Figure 1.19: This photograph was taken using an electron microscope and shows bacteria that can live in the alimentary canal, and can make you feel ill. It has been magnified approximately 10000 times.

You will meet bacteria at various stages in your biology course. Some of them are harmful to us and cause diseases such as cholera. Many more, however, are helpful. You will find out about their useful roles in the carbon cycle and the nitrogen cycle in Chapter 18, and their uses in biotechnology in Chapter 20.

Some bacteria can carry out photosynthesis. The oldest fossils belong to this kingdom, so we think that they were among the first kinds of organism to appear on Earth. Recently, biologists have discovered bacteria living in rocks more than 3 km beneath the Earth's surface.

Most organisms belonging to this kingdom are unicellular, and so their characteristic features are to do with the structure of their cells. This is described in more detail in Chapter 2, where you will find explanations of some of the terms below that may be unfamiliar (for example: mitochondria, plasmids).

Characteristic features of prokaryotes:

- They are usually unicellular (single-celled).
- They have no nucleus.
- They have cell walls, not made of cellulose.
- They have no mitochondria.
- They have a circular loop of DNA, which is free in the cytoplasm.
- They often have plasmids.

Questions

5 *Staphylococcus aureus* is a bacterium that is often found on human skin.
   - **a** Name the genus to which this bacterium belongs.
   - **b** Name the kingdom to which this bacterium belongs.
   - **c** Describe **two** ways in which the structure of *Staphylococcus aureus* differs from the structure of a plant cell.

6 Figure 1.20 shows part of a fungus. The photograph was taken with an electron microscope.
   - **a** Name the structure labelled A.
   - **b** Explain how the cells in this structure differ from the cells of an organism belonging to the animal kingdom.
   - **c** The structure labelled B contains spores. What is the function of this structure?

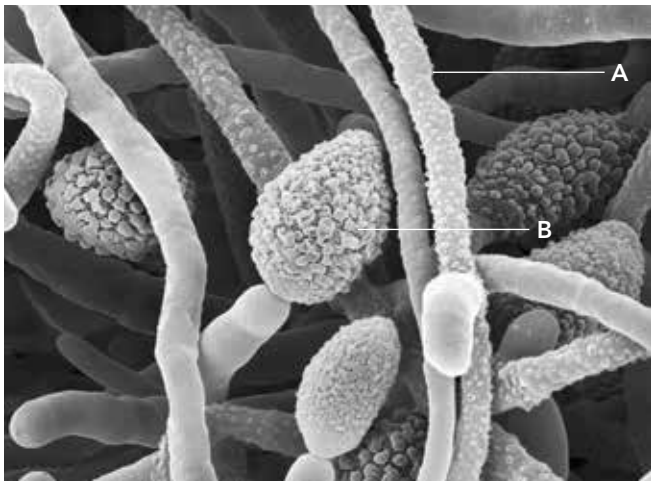


Figure 1.20: Part of a fungus.

ACTIVITY 1.3

Making a display about a kingdom of organisms

Work in a group of three or four for this activity.

In your group, choose one of the kingdoms of organisms. Try to make sure that at least one group is working on each kingdom.

Make a poster or other type of display, to describe the features of this kingdom. Include photographs or drawings of several different organisms that belong to this kingdom.

1.5 Groups within the animal and plant kingdoms

Within each kingdom, biologists classify organisms into smaller groups. In the animal kingdom, these groups include vertebrates and arthropods. If you are studying the Supplement, you also need to know about some of the groups in the plant kingdom.

Vertebrates

Vertebrates are animals that have backbones. These are the most familiar animals – fish, amphibians, reptiles, birds and mammals.

Fish

Fish (Figures 1.21 and 1.22) all live in water, apart from a few species such as mudskippers that are able to come onto land for short periods of time.

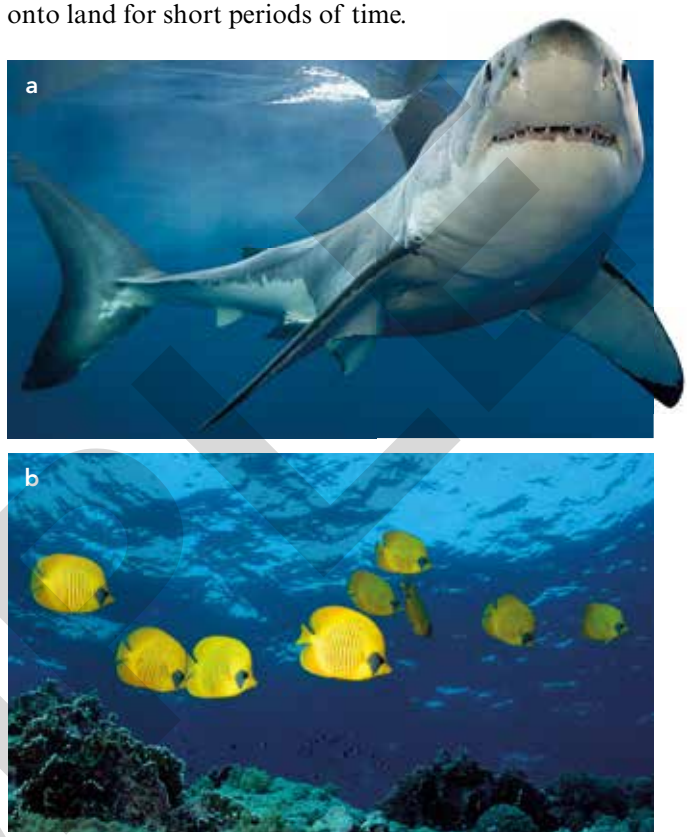


Figure 1.21 a: A great white shark. **b:** Masked butterfly fish.

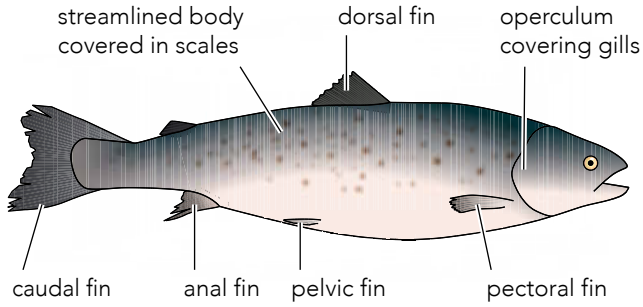


Figure 1.22: A fish.

Characteristic features of fish:

- They are vertebrates with scaly skin.
- They have gills throughout their life.
- They have fins.
- Their eggs have no shells and are laid in water.

Amphibians

Most adult amphibians live on land. However, they always go back to the water to breed. The larvae are called tadpoles, and they spend the first part of their life in water. They then undergo a major change in the shape of their body, called **metamorphosis**, as they become an adult. Frogs, toads and salamanders are amphibians (Figures 1.23 and 1.24).

Characteristic features of amphibians:

- They are vertebrates with skin with no scales.
- Their eggs have no shells and are laid in water.
- The tadpoles live in water, but adults often live on land.
- The tadpoles have gills for gas exchange, but adults have lungs.

Figure 1.23: Two examples of amphibians: **a:** a salamander **b:** a toad.

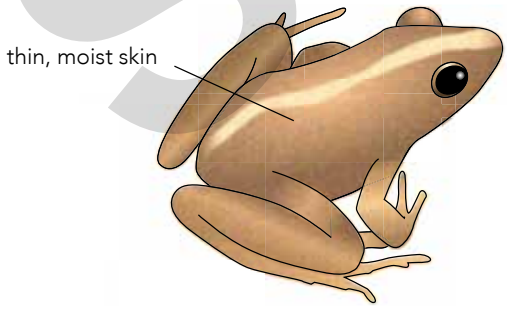


Figure 1.24: A frog, an example of an amphibian.

KEY WORD

metamorphosis: changing from a larva with one body form to an adult with a different body form

Reptiles

These are the crocodiles, lizards, snakes, turtles and tortoises (Figures 1.25 and 1.26). Reptiles all have scales on their skin. Unlike amphibians, reptiles do not need to go back to the water to breed because their eggs have a soft but waterproof shell which stops them from drying out.

Figure 1.25 a: This Nile crocodile has just hatched from its soft-shelled egg. **b:** Dinosaurs, including *Tyrannosaurus rex*, are a group of reptiles that became extinct about 65 million years ago, but we know a lot about them from fossils.

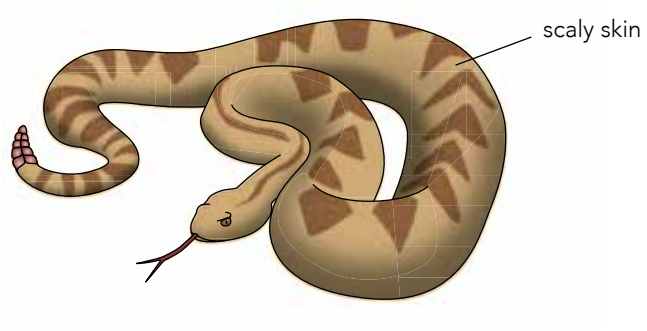


Figure 1.26: A snake, an example of a reptile.

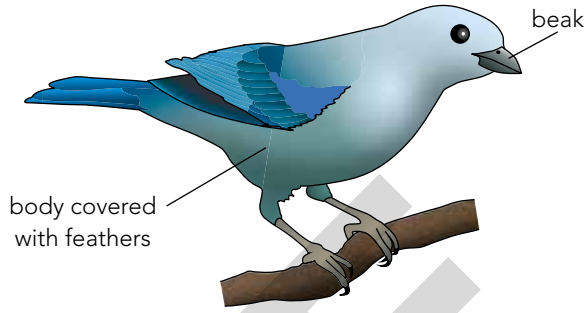


Figure 1.28: A bird.

Characteristic features of reptiles:

- They are vertebrates with scaly skin.
- They lay eggs with soft shells.

Birds

Birds evolved from dinosaurs, and some biologists consider that they are 'dinosaurs with feathers'. Birds are easy to identify, because they are the only animals with feathers (Figures 1.27 and 1.28). However, they sometimes do have scales – like reptiles – but generally only on their legs. The other very distinctive feature is their beak.

Characteristic features of birds:

- They have feathers (and also sometimes a few scales).
- They have a beak.
- Their front two limbs are wings (though not all birds can fly).
- They lay eggs with hard shells.

Figure 1.27 a: Although ostriches have wings, they cannot fly. **b:** The oriental dwarf kingfisher lives in forests in India and south east Asia. Despite its name, it eats small frogs and crickets rather than fish.

Mammals

The mammals are the most familiar vertebrates, and people who have not studied biology often use the word 'animal' to mean 'mammal'. Humans, of course, are mammals.

Some of the features of mammals are shared with birds. For example, both mammals and birds control their body temperature (see Chapter 13) and have a heart with four chambers (compartments) (see Chapter 9). Mammals also give birth to live young, but this is not helpful in identifying them, because many fish and reptiles also do this.

The easiest way to identify a mammal is that its skin has hair (Figures 1.29 and 1.30). Looking more closely, we find that their ears have a **pinna** (ear flap) on the outside, and that they have different kinds of teeth. But it is their method of reproduction and caring for their young that is most distinctive. Only mammals have a uterus and **placenta** (Chapter 15), and only mammals have **mammary glands** that produce milk to feed their young.

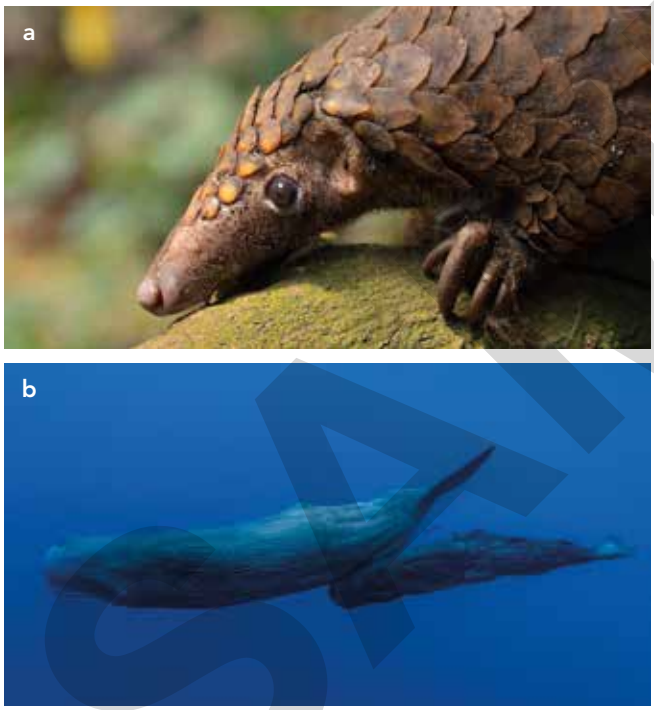


Figure 1.29: Two examples of mammals: **a:** A pangolin may look like a reptile at first glance, but if you look closely you can see hairs on its face and feet. **b:** A baby sperm whale sucks milk from its mother's mammary glands.

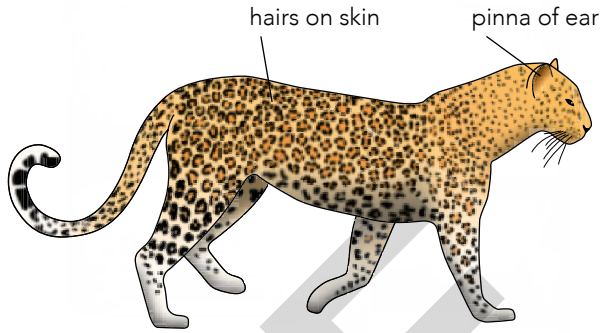


Figure 1.30: Some of the visible external features of a mammal.

Characteristic features of mammals:

- They have hair on their skin.
- Their young develop in a uterus, attached to the mother by a placenta.
- The females have mammary glands, which produce milk to feed their young.
- They have different kinds of teeth (incisors, canines, premolars and molars).
- They have a pinna (ear flap) on the outside of the body.
- They have sweat glands in the skin.
- They have a **diaphragm**.

KEY WORDS

pinna: a flap on the outside of the body that directs sound into the ear

placenta: an organ that connects the growing fetus to its mother, in which the blood of the fetus and mother are brought close together so that materials can be exchanged between them

mammary glands: organs found only in mammals, which produce milk to feed young

diaphragm: a muscle that separates the chest cavity from the abdominal cavity in mammals; it helps with breathing

Questions

7 Name the kingdom to which mammals belong.

8 List **two** differences between amphibians and reptiles.

9 List **a** two *external* and **b** two *internal* features of mammals that are not found in other groups of vertebrates.

Arthropods

Arthropods are animals with jointed legs, but no backbone. They are a very successful group, because they have a waterproof **exoskeleton**. An exoskeleton is on the outside of the body, rather than on the inside like yours. The exoskeleton supports arthropod bodies, and also allows these animals to live on land without drying out. There are more kinds of arthropod in the world than all the other kinds of animal put together.

Characteristic features of all arthropods:

- They have several pairs of jointed legs.
- They have an exoskeleton.

There are several different groups of arthropods, including insects, crustaceans, arachnids and myriapods.

Insects

Insects (Figures 1.31 and 1.32) are a very successful group of arthropods. Their success is mostly due to their exoskeleton and tracheae, which are very good at stopping water from evaporating from the insects' bodies, so they can live in very dry places. They are mainly **terrestrial** (land-living).

Characteristic features of insects:

- They are arthropods with three pairs of jointed legs.
- They have two pairs of wings (one or both may be **vestigial**).
- They breathe through tubes called tracheae.
- Their body is divided into a head, thorax and abdomen.
- They have one pair of antennae.

Figure 1.31: A dragonfly, an example of an insect.

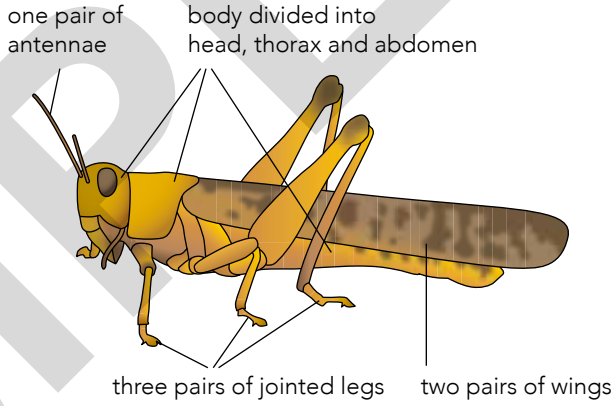


Figure 1.32: Features of a typical insect.

KEY WORDS

arthropod: an animal with jointed legs, but no backbone

exoskeleton: a supportive structure on the outside of the body

terrestrial: living on land

vestigial: description of a structure that has evolved to become so small that it is no longer useful

Crustaceans

These are the crabs, lobsters and woodlice (Figures 1.33 and 1.34). They breathe through gills, so most of them live in wet places and many are **aquatic** (live in water).

Characteristics:

- They are arthropods with more than four pairs of jointed legs.
- They have two pairs of antennae.

Figure 1.33: A lobster, an example of a crustacean. You can clearly see the two pairs of antennae on its head.

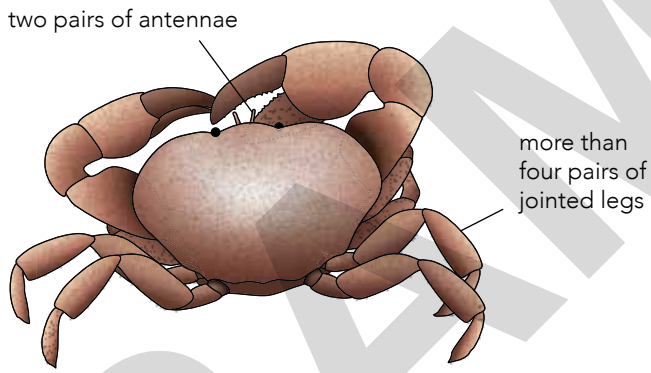


Figure 1.34: Features of a crustacean.

KEY WORD

aquatic: living in water

Arachnids

These are the spiders, ticks and scorpions (Figures 1.35 and 1.36). Arachnids are generally land-dwelling organisms.

Characteristics:

- They are arthropods with four pairs of jointed legs.
- They have no antennae.
- Their body is divided into two parts – a cephalothorax and abdomen.

Figure 1.35: A scorpion, an example of an arachnid.

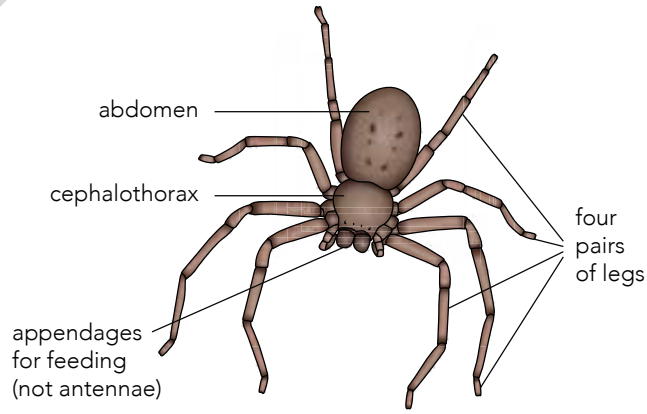


Figure 1.36: Features of an arachnid.

Myriapods

These are the centipedes and millipedes (Figures 1.37 and 1.38).

Characteristics:

- Their body consists of many similar segments.
- Each of their body segments has jointed legs.
- They have one pair of antennae.

Figure 1.37: A giant African millipede, an example of a myriapod.

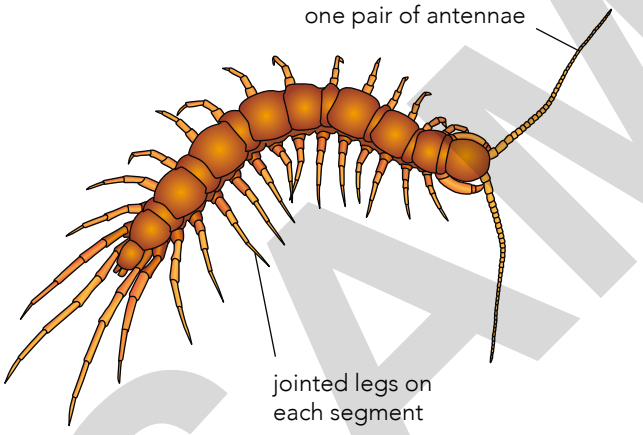


Figure 1.38: Features of a myriapod.

Questions

10 **a** List **two** features that are shared by myriapods and arachnids.

b Describe **two** differences between myriapods and arachnids.

11 Fleas are insects, but they do not have wings. Suggest **two** features of fleas that would show that they should be classified as insects.

ACTIVITY 1.4

Classifying animals

In this activity, you practise identifying the classification groups to which animals belong.

You will need:

- pictures or specimens of different vertebrates and arthropods, arranged around the room
- (optional) a clipboard.

Work with a partner for this activity.

First, read ahead to find out what you are going to do. On a sheet of paper, draw a table in which you can fill in your answers.

Look carefully at the first specimen. Discuss with your partner whether it is a vertebrate or an arthropod, and then decide which smaller group it belongs to within these two large groups.

Write down your decision, and the reasons for it.

Repeat for as many of the other specimens as you have time for.

REFLECTION

How are you going to try to remember the features of the four groups of arthropods? Which of these ideas, or a combination of them, do you think might work best for you?

- looking at labelled diagrams and reading lists of features
- trying to write your own list of features
- writing features on cards and then sorting them to match each group
- testing a friend or asking them to test you.

Ferns

Ferns are plants with leaves called fronds (Figures 1.39 and 1.40). They do not produce flowers, but instead reproduce by means of spores produced on the underside of the fronds. Most ferns are quite small, but some species can be as much as 20 m tall.

Characteristic features of ferns:

- They are plants with roots, stems and leaves (fronds).
- They do not produce flowers.
- They reproduce by spores produced on the undersides of their fronds.

Figure 1.39: Tree ferns in Bali, Indonesia.

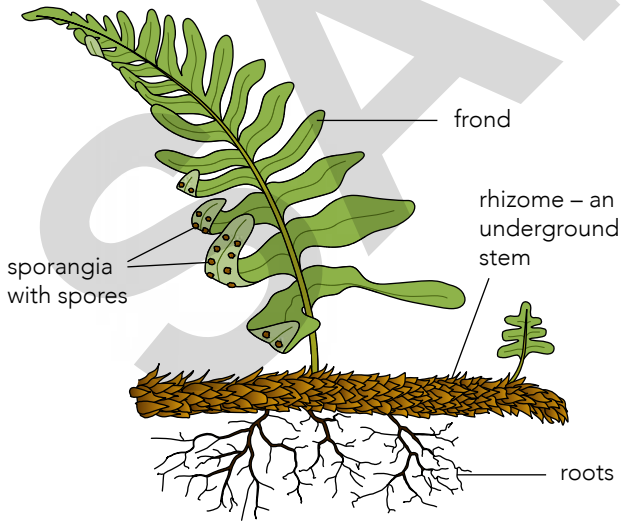


Figure 1.40: Features of a fern.

Flowering plants

These are the plants that are most familiar to us. As their name suggests, they reproduce by producing flowers (Figure 1.41). You will find out about their transport systems and method of reproduction in Chapters 8 and 14.

Characteristic features of flowering plants:

- They are plants with roots, stems and leaves.
- They reproduce using flowers and seeds.
- Their seeds are produced inside an ovary, in the flower.

Flowering plants can be divided into two main groups – **dicotyledons** and **monocotyledons**. These names refer to the structure of their seeds. The seeds of flowering plants contain 'seed leaves' or cotyledons. Monocotyledons (monocots for short) have only one cotyledon in their seeds, whereas dicotyledons (dicots) have two (Figures 1.41, 1.42 and 1.43).

Characteristic features of dicots:

- They have seeds with two cotyledons.
- They usually have a main root with side roots coming out from it.
- Their leaves have a network of veins.
- They have flower parts (e.g. petals) in multiples of four or five.
- They have vascular bundles in the stem, arranged in a ring (see Chapter 8).

Characteristic features of monocots:

- They have seeds with one cotyledon.
- Their roots grow out directly from the stem.
- Their leaves have parallel veins.
- They have flower parts in multiples of three.
- They have vascular bundles in the stem, arranged randomly.

KEY WORDS

dicotyledons: plants with two cotyledons in their seeds

monocotyledons: plants with only one cotyledon in their seeds

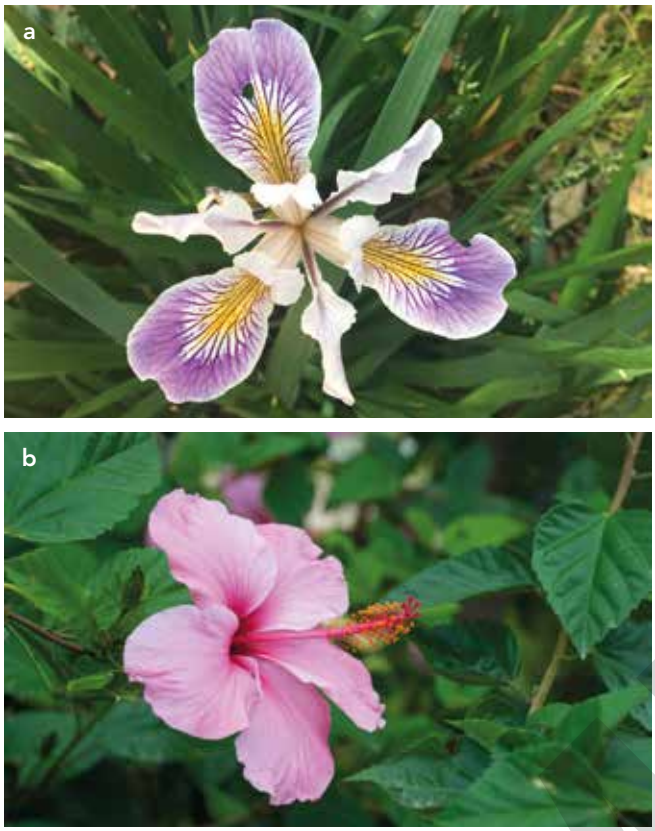


Figure 1.41: Two examples of flowering plants. **a:** An iris, an example of a monocot plant. **b:** Hibiscus, an example of a dicot plant.

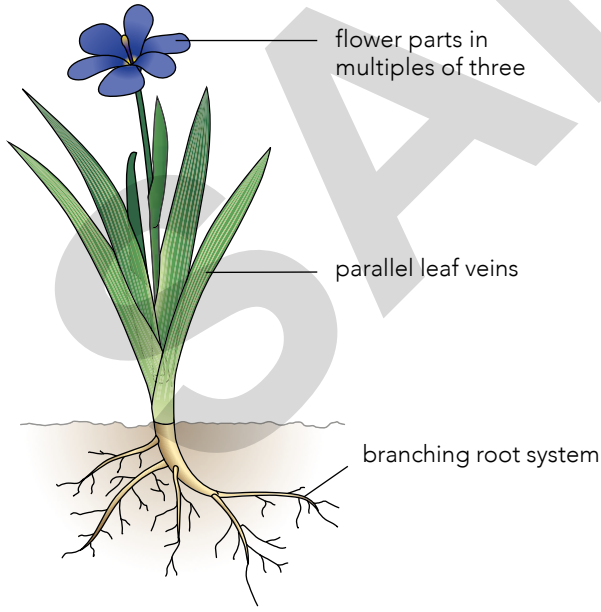


Figure 1.42: Features of a monocot plant.

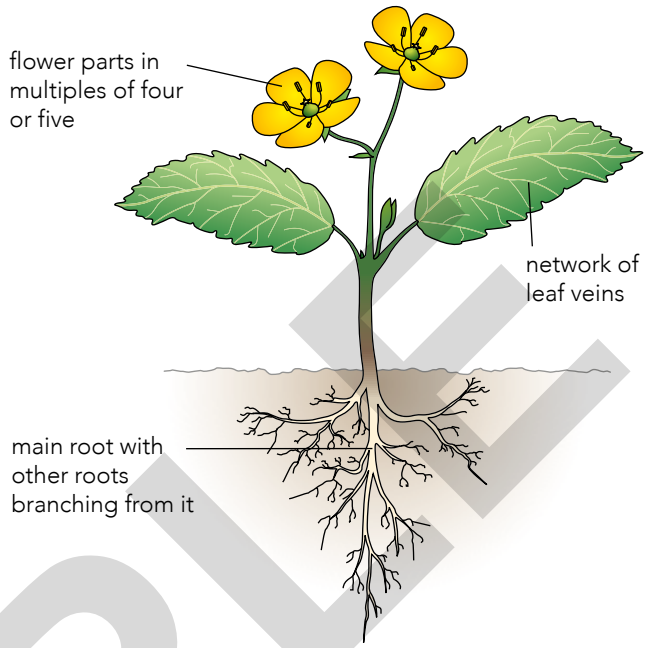


Figure 1.43: Features of a dicot plant.

Questions

12 Describe **two** differences between ferns and flowering plants.

13 In your local area, find two examples of monocotyledons and two examples of dicotyledons. Explain how you were able to decide which group each plant belonged to.

ACTIVITY 1.5

Classifying animals and plants

In this activity, you practise identifying the classification groups to which organisms belong.

You will need:

- pictures or specimens of organisms belonging to the animal, plant, fungus, prokaryote and protoctist kingdoms, arranged around the room
- pictures of ferns and flowering plants – some dicotyledons and some monocotyeldons, also arranged around the room
- (optional) a clipboard.

Work with a partner for this activity.

First, read ahead to find out what you are going to do. On a sheet of paper, draw a table in which you can fill in your answers.

Look carefully at the first specimen. Discuss with your partner which group it belongs to.

Write down your decision, and the reasons for it.

Repeat for as many of the other specimens as you have time for.

1.6 Viruses

You have almost certainly had an illness caused by a virus. Viruses cause common diseases such as colds and influenza, and also more serious ones such as AIDS.

Viruses are not normally considered to be living organisms because they cannot do anything other than just exist until they get inside a living cell. They then take over the cell's machinery to make multiple copies of themselves. These new viruses burst out of the cell and invade others, where the process is repeated. The host cell is usually killed when this happens. On their own, viruses cannot move, feed, excrete, show sensitivity, grow or reproduce. They do not display the seven characteristics of living things.

Figure 1.44 shows one kind of virus. It is not made of a cell – it is simply a piece of genetic material surrounded by a protein coat. It is hugely magnified in this diagram. The scale bar represents a length of 10 nanometres. One nanometre is 1×10^{-9} m. In other words, you could line up more than 15 000 of these viruses between two of the millimetre marks on your ruler.

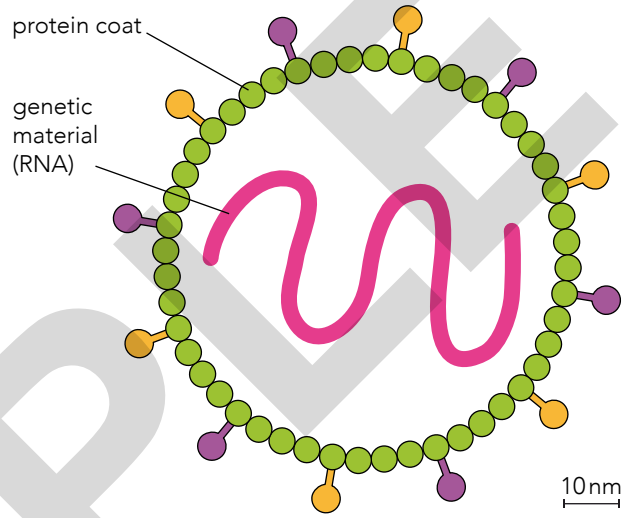


Figure 1.44: The structure of a virus.

Question

14 Figure 1.45 shows a virus. With reference to the diagram, and your own knowledge, discuss whether or not viruses can be considered to be living organisms.

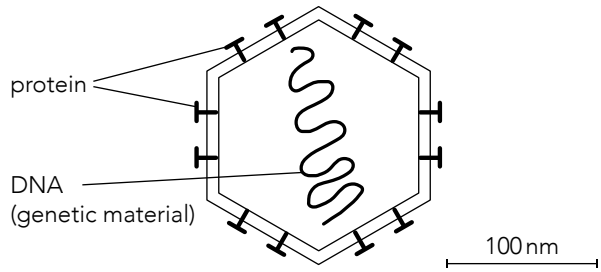


Figure 1.45: A virus.

SUMMARY

All organisms show seven characteristics: movement, respiration, sensitivity, growth, reproduction, excretion and nutrition.
Organisms are classified into groups according to features that they share.
Classification systems reflect evolutionary relationships between organisms.
The binomial system of naming organisms shows the genus and species. The name of the genus has a capital letter, followed by the name of the species with a small letter.
Dichotomous keys are used to identify organisms. They are made up of pairs of contrasting statements or questions. Taking one organism at a time, you work through the key until it leads you to the name of the organism.
When constructing a dichotomous key, it is important to make sure that a person using the key can make a decision looking at only one organism. Comparative or subjective descriptions (e.g. large, taller) are not suitable.
Organisms belonging to the plant kingdom have cells with cell walls made of cellulose, and some of their cells have chloroplasts. Organisms belonging to the animal kingdom have cells that do not have these features.
Vertebrates are animals with backbones. They are classified in five main groups: fish, amphibians, reptiles, birds and mammals, each with their own set of distinguishing features.
Arthropods are animals with an exoskeleton and jointed legs. They include insects, arachnids, crustaceans and myriapods, which can be distinguished from each other by the number of legs and antennae.
As well as the animal and plant kingdoms, organisms are classified into the fungus, prokaryote and protoctist kingdoms. They differ in the structure of their cells.
Ferns and flowering plants are two groups within the plant kingdom. Flowering plants can be classified as monocots or dicots, which differ in the patterns of veins in their leaves, the structure of their root systems, the number of flower parts and the distribution of vascular bundles in their stems.
Viruses are not classified in any of the five kingdoms, as they do not show the characteristics of living organisms. They do not have cells, and consist of genetic material surrounded by a protein coat.

PROJECT

A new species

Each year, biologists discover new species. Some of these are small (insects, small plants) while others are surprisingly large (mammals, trees).

Work in a group of three or four. Use the internet to search for some examples of newly discovered species and select one to research in detail.

Decide how you will share the results of your research with others. For example, you could give an illustrated talk, or produce a poster. Decide how you will share out the tasks between you.

Try to find information about some or all of these issues:

- Where and how was the new species discovered? Why had it not been discovered before?
- How did biologists decide that it really was a new species?
- How was the binomial for the new species chosen? What does its name mean?
- Biologists will want to find out more about the new species, but if it is rare they will not want to take many specimens from the wild, or disturb it in its habitat. How have these conflicts been resolved?

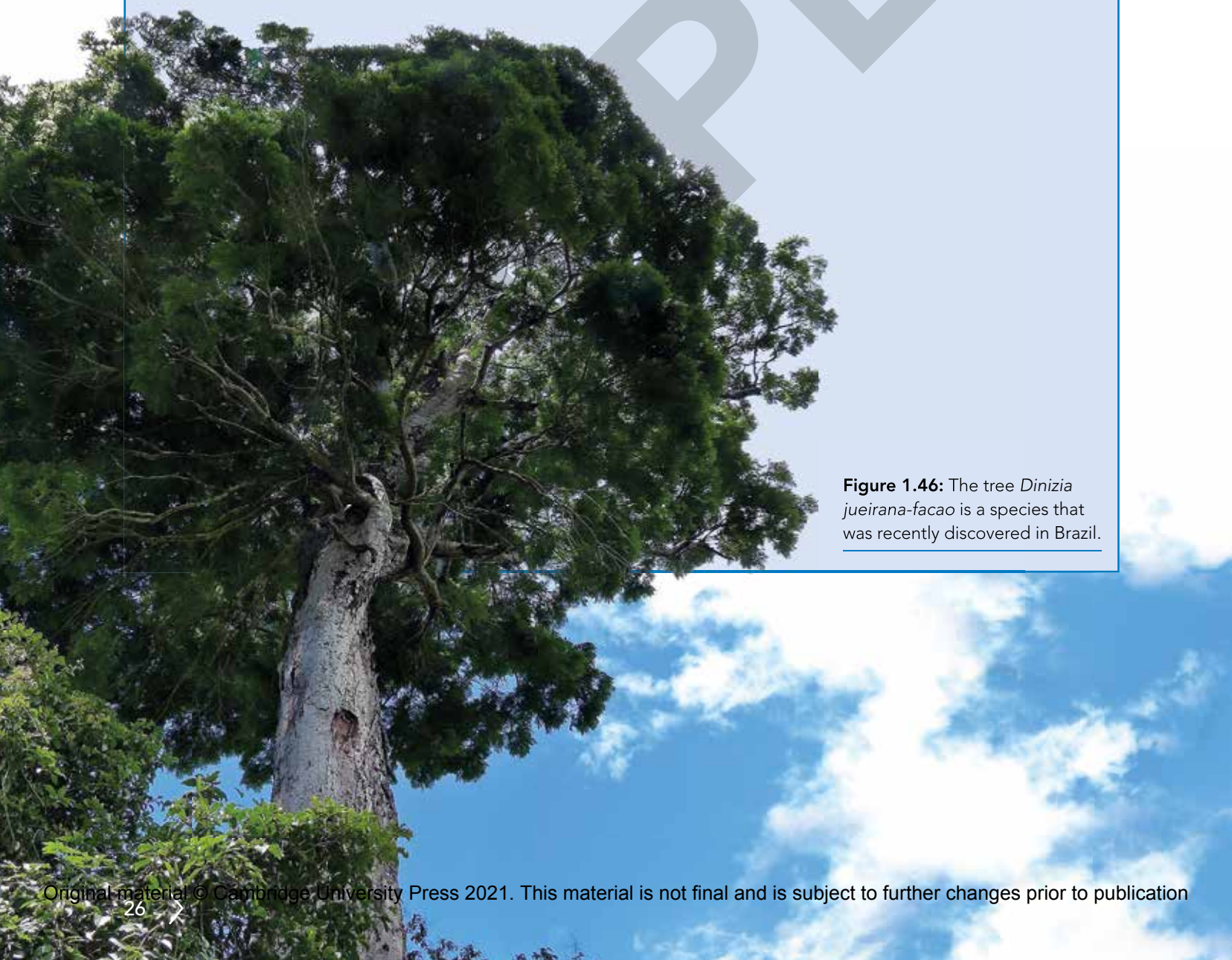


Figure 1.46: The tree *Dinizia jueirana-facao* is a species that was recently discovered in Brazil.

EXAM-STYLE QUESTIONS

1 Which characteristic is **not** shown by all living organisms?

A excretion
B movement
C photosynthesis
D respiration [1]

2 Which feature is found in all vertebrates and all arthropods?

A a backbone
B an exoskeleton
C antennae
D cells without cell walls [1]

3 The binomial of the okapi is *Okapia johnstoni*.
What genus does the okapi belong to?

A animals
B *johnstoni*
C mammals
D *Okapia* [1]

4 Which are features of monocotyledons?

A flower parts in multiples of four or five, one cotyledon in seeds
B one cotyledon in seeds, vascular bundles in a ring
C vascular bundles in a ring, network of veins in leaf
D parallel veins in leaf, flower parts in multiples of three [1]

5 What two features do all viruses possess?

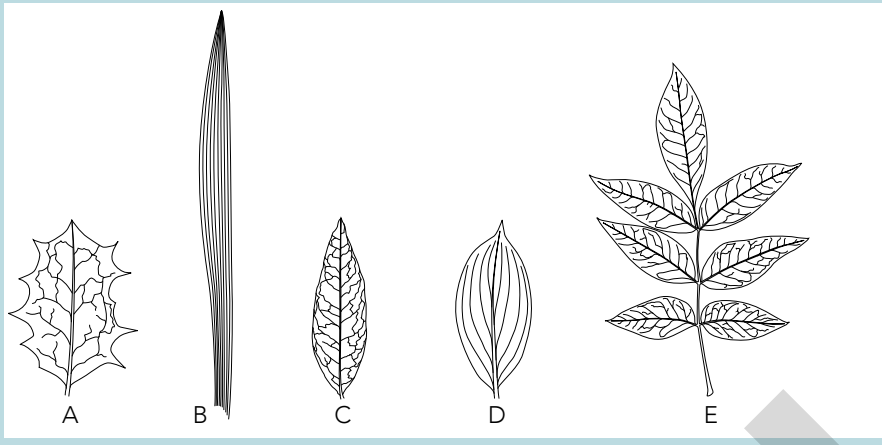
A cell membrane, cell wall
B cytoplasm, nucleus
C genetic material, protein coat
D ribosomes, plasmids [1]

TIP

The mark allocation for a question will often indicate the number of points that you should make, in order to fully answer that question.

CONTINUED

6



a The diagram above shows five leaves. Use the key to **identify** the species of plant that each of these leaves came from.

1	**(a)**	veins are parallel	**go to 2**
	(b)	veins are branching	**go to 3**
2	**(a)**	the leaf is more than 5 times as long as it is wide	*Iris germanica*
	(b)	the leaf is less than 5 times as long as it is wide	*Tricyrtis hirta*
3	**(a)**	leaf has a prickly edge	*Ilex aquifolium*
	(b)	leaf does not have a prickly edge	**go to 4**
4	**(a)**	leaf is divided into many leaflets	*Fraxinus excelsior*
	(b)	leaf is not divided into many leaflets	*Buddleia davidii*

[4]

b i **Explain** the meaning of the term *species*. **[2]**

ii Biologists give each species a two-word Latin name.
What is the term used to describe this naming system? **[1]**

[Total: 7]

7 The table shows features of three animals.

Animal	Exoskeleton	Number of jointed legs	Number of antennae
P	yes	four pairs	none
Q	yes	three pairs	one pair
R	yes	more than five pairs	one pair

a Name the major group that **all** of these animals belong to. **[1]**

b Each animal is classified into a smaller group within this major group.
Name the smaller group into which each animal is classified. **[3]**

c List **two** features, other than those shown in the table, that animal Q has, which are **not** shared with animals P and R. **[2]**

[Total: 6]

COMMAND WORDS

identify: name / select / recognise

explain: set out purposes or reasons / make the relationships between things evident / provide why and/or how and support with relevant evidence

CONTINUED

8 Three species of tree have the following Latin names:

- *Carpodiptera africana*
- *Commiphora africana*
- *Commiphora angolensis*

a Which **two** species do biologists consider to be the most closely related? Explain your answer. **[2]**

b *Commiphora africana* is a dicotyledon.

State **two** features that it shares with all other dicotyledons, but **not** with monocotyledons. **[2]**

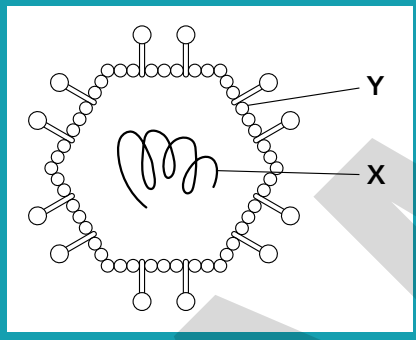
[Total: 4]

9 All living organisms are classified into five kingdoms. These include the plant, animal and fungus kingdoms.

a Name the other two kingdoms. **[2]**

b Describe **two** ways in which the cells of fungi differ from those of plants. **[2]**

c The diagram below shows a virus.



i Name parts **X** and **Y**. **[2]**

ii Explain why viruses are not generally classified into any of the five kingdoms. **[2]**

[Total: 8]

SELF-EVALUATION CHECKLIST

After studying this chapter, think about how confident you are with the different topics. This will help you to see any gaps in your knowledge and help you to learn more effectively.

I can	See Topic…	Needs more work	Almost there	Confident to move on
describe the seven characteristics of living organisms	1.1			
explain that organisms are classified according to features that they share	1.2			
explain that biologists classify organisms according to their evolutionary relationships	1.2			
describe and use the binomial naming system	1.2			
construct and use dichotomous keys	1.3			
state the main features of the animal and plant kingdoms	1.4			
state the main features of the fungus, prokaryote and protoctist kingdoms	1.4			
state the main features of the five groups of vertebrates – fish, amphibians, reptiles, birds and mammals	1.5			
state the main features of the four groups of arthropods – insects, crustacea, arachnids and myriapods	1.5			
state the main features of two groups of plants – ferns and flowering plants, including dicots and monocots	1.5			
state the main features of viruses	1.6			

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Biology

for Cambridge IGCSE™

Digital Teacher's Resource

Cambridge Assessment International Education
Endorsed for teacher support

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How to use this Teacher's Resource

This Teacher's Resource contains both general guidance and teaching notes that help you to deliver the content in our Cambridge resources.

There are **teaching notes** for each chapter of the Coursebook. Each set of teaching notes contains the following features to help you deliver the chapter.

At the start of each chapter there is a **teaching plan** (see below). This summarises the topics covered in the chapter, including the number of learning hours recommended for each topic, an outline of the learning content, and the Cambridge resources from this series that can be used to deliver the topic.

Topic	Approximate number of learning hours	Learning content	Resources
1.1 Characteristics of living organisms	0.5	Core: Describe the characteristics of living organisms by describing: • movement as an action by an organism or part of an organism causing a change of position or place • respiration as the chemical reactions in cells that break down nutrient molecules and release energy for metabolism • sensitivity as the ability to detect and respond to changes in the internal or external environment • growth as a permanent increase in size and dry mass • reproduction as the processes that make more of the same kind of organism • excretion as removal of the waste products of metabolism and substances in excess of requirements • nutrition as taking in of materials for energy, growth and development.	**Coursebook:** Exam-style questions 1 and 2 **Workbook:** Exercise 1.1: Characteristics of living organisms Exercise 1.2: The biological classification system Exercise 1.3: Keys

1.2 Concept and uses of a classification system	2	**Core:** State that organisms can be classified into groups by the features that they share. Describe a species as a group of organisms that can reproduce to produce fertile offspring. Describe the binomial system of naming species as an internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species. Construct and use dichotomous keys based on identifiable features. **Supplement:** Explain that classification systems aim to reflect evolutionary relationships. Explain that the sequences of bases in DNA are used as a means of classification. Explain that groups of organisms which share a more recent ancestor (are more closely related) have base sequences in DNA that are more similar than those that share only a distant ancestor.	**Practical Workbook:** Practical investigation 1.1: Construct a dichotomous key **Coursebook:** Exam-style questions 3 and 6 **Workbook:** Exercises 1.4 and 1.5: Keys
1.3 Features of organisms	2	**Core:** State the main features used to place organisms into the appropriate kingdoms. State the main features used to place organisms into: • the main groups of vertebrates: mammals, birds, reptiles, amphibians, fish • the main groups of arthropods: myriapods, insects, arachnids, crustaceans. Classify organisms using the features identified above. **Supplement:** State the main features used to place all organisms into one of the five kingdoms: animal, plant, fungus, prokaryote, protoctist. State the main features used to place organisms into groups within the plant kingdom, limited to ferns and flowering plants (dicotyledons and monocotyledons). Classify organisms using the features identified above. State the features of viruses, limited to a protein coat and genetic material.	**Coursebook:** Exam-style question 7

The topic order generally follows the same sequences as the topics in the syllabus with some exceptions where appropriate.

Content that is aimed at learners who are studying the **Supplement** is shown in blue in the teaching plan, and there is an arrow to the left of the table.

Each chapter also includes information on any **background knowledge** that learners should have before studying this chapter, advice on helpful **language support**, and a **teaching skills focus** that will help you develop your skills across a number of key pedagogical areas.

These boxes tell you where information in the book is extension content, and is not part of the syllabus.

At the beginning of the teaching notes for the individual topics there is an outline of the **learning objectives** (see Learning Plan below) for that topic, as well as any **common misconceptions** that learners may have about the topic and how you can overcome these. Syllabus learning objectives for learners who are studying the Supplement are indicated in the table in a darker blue colour, with an arrow on the left.

LEARNING PLAN

Syllabus learning objectives	Learning intentions	Success criteria
Core: State that organisms can be classified into groups by the features that they share. Describe a species as a group of organisms that can reproduce to produce fertile offspring. Describe the binomial system of naming species as an internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species. Construct and use dichotomous keys based on identifiable features. Supplement: Explain that classification systems aim to reflect evolutionary relationships. Explain that the sequences of bases in DNA are used as a means of classification. Explain that groups of organisms which share a more recent ancestor (are more closely related) have base sequences in DNA that are more similar than those that share only a distant ancestor.	In this topic, learners will: • find out how the binomial system is used to name organisms discover the relationship between DNA and classification.	Learners will be able to determine how an unfamiliar species is classified and apply knowledge to explain this process.

For each topic, there is a selection of **starter ideas**, **main activities** and **plenary ideas**. You can pick out individual ideas and mix and match them depending on the needs of your class. The activities include suggestions for how they can be differentiated or used for assessment. Many of the **challenge ideas** focus on Assessment Objective 2, and require learners to apply the concepts of the syllabus to new situations.

Homework ideas give suggestions for tasks, along with advice for how to assess learners' work.

The teaching notes for each chapter also include **practical work guidance** to support you in teaching the exercises in the Practical Workbook, and any **model data** that accompany the Practical Workbook chapter.

1 Characteristics and classification of living organisms

Teaching plan

Topic	Approximate number of learning hours	Learning content	Resources
1.1 Characteristics of living organisms	0.5	Core: Describe the characteristics of living organisms by describing: • movement as an action by an organism or part of an organism causing a change of position or place • respiration as the chemical reactions in cells that break down nutrient molecules and release energy for metabolism • sensitivity as the ability to detect and respond to changes in the internal or external environment • growth as a permanent increase in size and dry mass • reproduction as the processes that make more of the same kind of organism • excretion as removal of the waste products of metabolism and substances in excess of requirements • nutrition as taking in of materials for energy, growth and development.	**Coursebook:** Exam-style question 1 **Workbook:** Exercise 1.1: Characteristics of living organisms Exercise 1.2: The biological classification system Exercise 1.3: Keys

(Continued)

1.2 Concept and uses of a classification system	2	**Core:** State that organisms can be classified into groups by the features that they share. Describe a species as a group of organisms that can reproduce to produce fertile offspring. Describe the binomial system of naming species as an internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species. Construct and use dichotomous keys based on identifiable features. **Supplement:** Explain that classification systems aim to reflect evolutionary relationships. Explain that the sequences of bases in DNA are used as a means of classification. Explain that groups of organisms which share a more recent ancestor (are more closely related) have base sequences in DNA that are more similar than those that share only a distant ancestor.	**Practical Workbook:** Practical investigation 1.1: Construct a dichotomous key **Coursebook:** Exam-style questions 3 and 6 **Workbook:** Exercises 1.4 and 1.5: Keys
1.3 Features of organisms	2	**Core:** State the main features used to place organisms into the appropriate kingdoms. State the main features used to place organisms into: • the main groups of vertebrates: mammals, birds, reptiles, amphibians, fish • the main groups of arthropods: myriapods, insects, arachnids, crustaceans. Classify organisms using the features identified above. **Supplement:** State the main features used to place all organisms into one of the five kingdoms: animal, plant, fungus, prokaryote, protoctist. State the main features used to place organisms into groups within the plant kingdom, limited to ferns and flowering plants (dicotyledons and monocotyledons). Classify organisms using the features identified above. State the features of viruses, limited to a protein coat and genetic material.	**Coursebook:** Exam-style questions 2, 4 and 7–9

BACKGROUND KNOWLEDGE

- Learners will have some knowledge of the characteristics of living organisms. Even if learners have not followed the Cambridge Lower Secondary course, they will have an understanding of the difference between the terms living and non-living.
- Learners probably know that organisms can be classified into groups that share features. If they do not, ask them to consider a small number of animals and consider how they could be grouped (e.g. frog, lizard, shark and human can be divided into two groups: those that have a tail (lizard and shark) and those that do not (frog and human)).
- Learners do not know how to classify organisms using dichotomous keys.
- Learners do not know the broad range of categories to which organisms can belong. These include the kingdoms of life and the different animal groups (such as mammals, reptiles and birds).

TEACHING SKILLS FOCUS

Area of focus: In this chapter, there are many opportunities for learners to engage with active learning. This approach is sometimes described as 'learning by doing' and involves activities including talking, making, writing and performing. Examples include the tasks entitled: Converting definitions into drawings, Characteristics card sort, Key circus, The DNA clock and Classification winning cards.

Specific focus: The specific focus of these active learning tasks is to provide learner-centred active learning opportunities. Here, learners play an active role in their learning, with the teacher as a facilitator, rather than as an instructor. Despite being fact-led, learning science is about constructing meaning for abstract ideas. Learner-centred active learning opportunities enable learners to make their own meaning of the concepts.

Benefits: The benefit for learners of this approach is that they develop a responsibility for their learning (called autonomy) and a deeper understanding of the material, rather than a superficial ability to recall information. This is in keeping with the idea of constructivism, which describes how learners build their own understanding, and contrasts with a model of instruction whereby knowledge is imparted or transmitted from the teacher. While learners are busy working, you have the opportunity to move around the class and respond to learners' individual needs.

Develop: Careful planning in advance of the lesson is important to ensure that equipment is organised, photocopies have been made and appropriate seating arrangements to promote group work have been considered. If your school guidelines permit, use a school tablet to take photographs and share them with your learners at the end of the lesson. This can help to record and reinforce their feelings of pride, initiative, motivation and commitment.

Reflection: To consider how effectively you responded to the challenge of using learner-centred active learning opportunities, ask yourself the following questions.

1 Do you feel that the learners have developed a deeper understanding of the concept, than if you had simply told them the facts? If so, why?

2 During the task, did you at any time feel you had lost control of the class and its learning direction? It is quite common to answer 'yes' to this question. However, with more practice, learners become more used to learning in active tasks and it will be more comfortable for you to host the activity. During this task, if you feel that your learners are losing focus, try gaining their attention for a few seconds. Ask them all to raise their hands and look at you for a reminder of the instructions or expectations, or to stand up and stretch their arms out in the air as you give them a reminder of the time remaining. These interventions will help you get them back on track.

CONTINUED

3 What could you do differently next time you host this activity? Think about aspects such as organisation, pace and the questions you asked the learners. How could you help your learners appreciate that understanding the content of the syllabus is more important than memorising it?

LANGUAGE SUPPORT

For many learners, this chapter will be the first to be studied in the syllabus. The wide variety of terms that they meet in this topic provides an opportunity to develop good habits in note-taking, such as underlining and highlighting key terms or building a glossary as they go.

In each lesson, it is a good idea to write the key words on the board for the duration of the lesson.

Activities that explicitly focus on key terms from this topic are recommended, especially those related to the seven characteristics of life, and the names of the taxa. Crosswords, anagrams and missing-word exercises can help learners get to know how to spell and attach meaning to the key terms.

Techniques such as 'taboo', in which learners work in pairs to describe key ideas to each other, but without using key words defined by the teacher, are useful. It would be challenging, for example, for learners to describe the features of plants without using the three key words: leaves, photosynthesis and green.

For definitions of key words please refer to the Glossary.

1.1: Characteristics of living organisms

LEARNING PLAN

Syllabus learning objectives	Learning intentions	Success criteria
Core: Describe the characteristics of living organisms by describing: • movement as an action by an organism or part of an organism causing a change of position or place • respiration as the chemical reactions in cells that break down nutrient molecules and release energy for metabolism • sensitivity as the ability to detect and respond to changes in the internal or external environment • growth as a permanent increase in size and dry mass • reproduction as the processes that make more of the same kind of organism	In this topic, learners will: • learn about the seven characteristics of living organisms.	Learners will be able to decide whether an organism is living or non-living and explain the difficulty in determining whether or not some characteristics apply in some cases.

CONTINUED

Syllabus learning objectives	Learning intentions	Success criteria
• excretion as the removal of the waste products of metabolism and substances in excess of requirements • nutrition as the taking in of materials for energy, growth and development.		

Common misconceptions

Misconception	How to identify	How to overcome
Learners often perceive plants as organisms that are somehow 'less alive' than animals.	Ask learners a 'trick question' – ask them to rank order a human, a plant and a bacterium, but do not specify on which terms. Ask one or two learners to explain their choice.	Emphasise that all seven characteristics of living organisms apply to all living organisms; they are just more visible in some organisms than others.
Learners often assume that plants do not move.	Ask learners to list organisms that appear, at first glance, not to have any of the characteristics of life.	Draw a distinction between movement and locomotion. Plants are not capable of locomotion.
Respiration is often mistaken for breathing or gas exchange.	Ask learners whether a plant (or another organism that does not ventilate) respires.	Emphasise that the term respiration refers to metabolism; explore the meaning of this term.
Egestion is often thought of as a type of excretion. Related to this, learners also assume that plants do not excrete.	Challenge learners to list the materials that they consider to be waste, and then decide if removing each of these can be considered an example of excretion.	Underline the term 'metabolic' in the definition of excretion and build an understanding that the contents of faeces have never been a part of the body. Also draw attention to the carbon dioxide that organisms excrete; emphasise that this is invisible.
Learners can overlook that unicellular organisms consist of only one cell.	Ask what bacteria, yeast and some other unicellular organisms have in common.	Draw attention to the prefix 'uni-', which is derived from the Greek for 'one'.

Starter ideas

1 Searching for similarities (15 minutes)

Resources: Coursebook, a potted plant and a desk lamp.

Description and purpose: Learners read and undertake the Getting started activity in the Coursebook. Extend this activity by holding a potted plant in one hand and a desk lamp in the other. Ask learners to think of features that you (as a human) and the potted plant have in common, which are not shared with the desk lamp. Engage learners in a 'think, pair, share' activity in which they have 10 seconds to think by themselves, then another 30 seconds to share their ideas with their partner. Then, select a number of learners at random from the class to share their ideas and build a common understanding of the characteristics of life.

What to do next: If learners found the activity difficult, recap the common features of animals and plants with them.

Getting started answers

1 excretion, sensitivity, growth, reproduction, movement, nutrition, respiration

2 See Topic 1.1 for full descriptions of each term. Learners are not likely to be able to describe each one correctly at this stage. Their answers will provide you with an opportunity to pick up any misconceptions.

2 Determining differences (15 minutes)

Description and purpose: Learners work in pairs to think of two organisms that are common in your school's host country. One must be an animal and one a plant. If they can, they should think of a third that must be neither an animal nor a plant (e.g. a fungus). After all pairs have decided on their three organisms (you could ask them to put their hands up when they are ready), provide a series of five statements that have the responses 'true' or 'false'. Examples could include, '*Your three organisms are made of cells*' (true) and '*Your three organisms can fly*' (false). Find out whether learners are familiar with the diversity of life on Earth through their personal experiences. However, there are some characteristics that are always true of all living organisms.

What to do next: It is probable that learners do not know the seven characteristics of life and their names, so write these on the board after the class discussion. These will serve as a reminder for learners to refer to as they undertake the subsequent activities.

Main teaching ideas

1 Converting definitions into drawings (30 minutes)

Learning intention: Learners describe the characteristics of living organisms by defining the seven characteristics of life.

Resources: Sheets of card that can be cut into small pieces (20 × 20 cm approx.).

Description and purpose: Provide learners with a sheet of card and a pair of scissors. Ask them to produce a series of seven flashcards that each show the name of a characteristic of life and its definition on one side. On the other side learners draw a sketch that represents the characteristic in a visual form. At the end of the task, shuffle all the cards (there will be seven times the number of learners) and hand out seven at random to each learner, face down on their desks. Learners should rank order the cards in terms of quality of communication – whether the sketch accurately reflects the characteristic – rather than drawing quality. This places an emphasis on helping learners understand the meaning of the characteristics, which can be difficult to consider from just the terminology.

Safety: Learners need to be careful when using the scissors.

› **Differentiation ideas:**

Support – During the activity, allow learners who find it difficult to get started with 'clue words' to help. For example, a learner may find it difficult to illustrate the concept of respiration. Provide them with a clue word such as 'gas', 'waste' or 'energy'.

Challenge – If any learners complete their sketches before the others, ask them to write a very short story about 'a day in the life of an animal or plant' and include the seven characteristics of life.

› **Assessment ideas:** Provide learners with a series of unfinished sentences that are written to reinforce their knowledge of this learning. Ask for learners to read out their ideas and ask for comments from other pairs. An example could be: 'All organisms undertake respiration, which is … .'

2 Characteristics card sort (30 minutes)

Learning intention: Learners describe the characteristics of living organisms by defining the seven characteristics of life.

Resources: Cards or small sheets of paper that have the characteristics of life written on some of them (e.g. 'can reproduce', 'can grow') and a wide range of other characteristics written on others (e.g. 'has a brain' and 'can carry blood in vessels').

Description and purpose: Before you start this activity, remove the characteristics of life if you had written them on the board. Give one pack of cards/paper sheets to each pair of learners. Encourage learners to sort through the cards and place them into two piles – one pile that contains features that apply to all living organisms, and one pile that applies to only some organisms. Then ask pairs of learners to swap seats and explore the decisions made by another pair of learners. Hold a class discussion to arrive at a common understanding.

Differentiation ideas:

Support – While learners are sorting their cards, periodically ask them to stop and reconsider. Ask questions to correct misconceptions if you spot incorrect decisions, and encourage learners' self-reflection. For example, some learners may consider respiration to be the same as breathing. Help learners to overcome this by informing them that plants also respire, but do not breathe.

Challenge – Challenge learners to discuss with each other how the seven characteristics of life can be applied to organisms in different ways, and whether groupings can be made. For example, with regard to reproduction, female humans, mice and bats give birth to live young; (most) reptiles, amphibians and fish lay eggs. Although it should not be acknowledged in this lesson, this activity is good preparation for subsequent lessons on classification.

Assessment ideas: Ask learners to think of a mnemonic for the first letter of each of the seven characteristics of life. The class could then vote for their favourite. 'MRS GREN' is a very common option, but are there others?

3 Workbook Exercise 1.1: Characteristics of living organisms (30 minutes)

Learning intention: Learners explore the characteristics of living organisms by considering the seven characteristics of life.

Resources: Workbook (Exercise 1.1)

Description and purpose: For learners to practise naming and describing the characteristics of living things.

Differentiation ideas:

Support – Provide learners with one of the five lines drawn between the terms and their definitions, to model how to answer the first (Focus) exercise.

Challenge – Encourage learners to complete the exercise within a very strict time limit. This could be as little as two minutes. Alternatively, follow the instructions regarding the Challenge activity that involves someone from another planet visiting Earth.

Assessment ideas: Ask learners to swap their Workbooks with a partner and assess each other's work. Ask the learners, 'Did your partner's answers match your own?' and, 'If there were any differences in your answers, discuss which is the correct answer and why.'

Plenary ideas

1 Living laboratory equipment? (15 minutes)

Resources: Laboratory equipment, balance, pH probes, thermometers and so on.

Description and purpose: Ask learners to consider how items of laboratory equipment or other items, such as a moving car, do satisfy *some* of the characteristics of life. For example, a thermometer is able to sense a change in the environment and the liquid inside it 'grows' in response.

2 Workbook Exercise 1.1: Characteristics of living organisms (10 minutes)

Resources: Workbook (Exercise 1.1)

Description and purpose: A task that requires learners to practise naming and describing the characteristics of living things. If learners didn't have time to complete the peer assessment, you could carry this out as a plenary activity.

Homework ideas

1 Summary questions

Questions related to this topic are exam-style question 1 in the Coursebook and Exercise 1.1 (Characteristics of living organisms) in the Workbook.

2 Create a characteristics crossword

Challenge learners to design a crossword (either with a pencil and paper or on a computer). The seven words should be the seven characteristics of life; they must write clues for another learner to find them.

The choice of which homework task to provide learners may depend on the time that they have available to devote to this. The Coursebook questions will require a greater time commitment. The crossword activity provides an opportunity for learners to be more creative. The follow-up assessment of either task will provide an opportunity for formative assessment: determining if learners have mastered these topics before moving on.

1.2: Concept and uses of a classification system

LEARNING PLAN

Syllabus learning objectives	Learning intentions	Success criteria
Core: State that organisms can be classified into groups by the features that they share. Describe a species as a group of organisms that can reproduce to produce fertile offspring. Describe the binomial system of naming species as an internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species. Construct and use dichotomous keys based on identifiable features. **Supplement:** Explain that classification systems aim to reflect evolutionary relationships. Explain that the sequences of bases in DNA are used as a means of classification. Explain that groups of organisms which share a more recent ancestor (are more closely related) have base sequences in DNA that are more similar than those that share only a distant ancestor.	In this topic, learners will: • find out how the binomial system is used to name organisms discover the relationship between DNA and classification.	Learners will be able to determine how an unfamiliar species is classified and apply knowledge to explain this process.

Common misconceptions

Misconception	How to identify	How to overcome
Learners often believe that organisms with similar features must be closely related – for example: birds, bats and bees.	Write on the board a number of organisms that can fly (e.g. insects, mammals and birds) and some that cannot fly. Ask learners to group them into categories – do learners base their grouping on flight as a first priority?	Although this is beyond what learners need to know, refer to how organisms sometimes have very similar features because they share an environment, not because they are related.
When using dichotomous keys, learners can jump to the end of the activity and look at all the organisms at once to try to match the descriptions with the organisms.	Provide a dichotomous key and challenge learners to answer it as quickly as they can. When they finish, they should turn over their sheet of paper.	Emphasise that those learners who have finished first have usually made the most mistakes. Tell learners that more accurate judgements are made by those who go through the key step by step.

(Continued)

Misconception	How to identify	How to overcome
When constructing dichotomous keys, learners can refer to subjective terms such as 'long' or 'dark'.	Ask learners to describe something that everyone can see – for example, your hair.	Draw attention to the fact that subjective terms require further qualification and therefore cannot be used in a dichotomous key.
Sometimes learners can mistakenly omit reference to 'pairs'; for example, pairs of legs.	Ask learners to list the differences in the number of appendages between different organisms, e.g. the arthropods.	Challenge learners to undertake calculations concerning multiple individuals from a species, e.g. 'How many legs do four insects have?' (answer: 24).

Starter ideas

1 Awkward animals (10 minutes)

Resources: Coursebook or short video clip from YouTube.

Description and purpose: Refer learners to the Science in context opening text in the Coursebook regarding the platypus. Alternatively, show a short video clip of the platypus or another animal that has unusual features – for example, the pangolin or an unusual animal that is native to the country your school is in. Discuss why this organism is difficult to classify. Elicit from learners that they already have predetermined thoughts about classifying organisms.

What to do next: Provide learners with the definition of a species, and explain that the organism that they have discussed satisfies this definition.

2 Species – towards a definition (10 minutes)

Description and purpose: Provide learners with marker pens and ask them to come to the class board to write down as many words that they can think of that relate to 'species'. Learners then return to their seats and work in pairs to construct a sentence that they feel defines this term. They may choose to use only some of the words, if they feel some are not relevant. Pairs of learners then join to form groups of four, then eight, and then elicit a definition that all learners agree on.

What to do next: Show learners examples of animals that have features normally associated with different groups, e.g. the platypus and the pangolin. Encourage a discussion to focus learners' attention on the definition of a species in the context of one of these animals.

Main teaching ideas

1 Key circus (40 minutes)

Learning intention: Learners explore how organisms can be classified into groups by studying the features that they share.

Resources: The contents of learners' stationery cases (pens, pencils, protractors etc.); nuts, bolts and screws of different sizes; eating utensils (forks, spoons, sporks, chopsticks etc.); laboratory equipment (plastic beakers, thermometers, spatulas and wooden splints). Note that these lists are not exhaustive: the more items, the better!

Description and purpose: Arrange learners into groups of four or five. For five minutes, each group works at one of a number of stations that have been arranged around the room. At each station are a number of items that share some (but not all) features. Learners decide which items have the most in common and give a rationale for their choices (e.g. forks and spoons have more in common than forks and chopsticks, but why?). Ask learners to suggest why we classify things. After five minutes, ring a bell that tells learners to move on to the next station. When each group has visited every station, learners return to their desks. Discuss learners' decisions. Learners then work in pairs or groups of three to construct a dichotomous key for each station that would allow another person to decide which item is which. Link the task with the syllabus content by discussing the ways in which organisms could be classified (e.g. by shared features, by shared ancestry, by where they live or by how useful they are to us). Finally, elicit an understanding of the term 'hierarchy'.

Safety: Some of the items you choose for the key circus may be sharp. Learners should handle them with care.

› **Differentiation ideas:**

Support – Ensure that the groups of four or five learners contain learners of different abilities. This will help scaffold the learning experience for all: the wide range of abilities will provide many viewpoints and perspectives.

Challenge – Move around the room during the activity and ask learners questions to extend understanding. For example, why is classification important? In this case, it would be important in a shop, but in the natural world? Could it play a role in conservation? Or medicine? Elicit answers from learners and help them to understand, for example, that grouping organisms into categories can provide hints to scientists that newly discovered organisms share more than just the obvious characteristics with those that are already well described.

› **Assessment ideas:** Ask learners to pose questions using 'question shells' on this topic. For example, 'Why is … an example of … ?' could be written on the board, with learners challenged to write questions for each other. This helps learners to commit to their choices. Examples could include:

- Why is a screw an example of a metallic object?
- Why is a tie an example of an item of clothing?
- Why is the thermometer an example of a measuring instrument?

2 Constructing keys (40 minutes)

Learning intention: Learners explore how organisms can be classified into groups by the features that they share. This idea uses the relevant content from the Coursebook.

Resources: Coursebook

Description and purpose: Arrange learners in pairs. Tell them that they must each determine what the other had for breakfast this morning (assuming they did), but only by asking questions for which 'yes' or 'no' can be the answer. Elicit an understanding that 'dichotomous' means 'has two branches' and that these yes/no questions are closed and eventually lead to the correct answer. If learners need further practice, ask them to design a dichotomous key that would allow them to identify one of their teachers. Once you feel that learners have enough confidence, instruct them to undertake Activity 1.2 in the Coursebook. In this activity, learners are challenged to work with a partner to write a key to enable someone to identify each of four flowers. Ensure that in this activity learners have some experience of using the binomial names and why these are important in accurately classifying organisms.

› **Differentiation ideas:**

Support – Ensure that the learners working in pairs have different strengths. This will help scaffold the learning experience for the less confident, but also provide an opportunity for more confident learners to practise their communication skills.

Challenge – Ask learners to carry out research to find how many species of the *Plasmodium* genus cause malaria. Why is it important that we know which type of parasite has infected a patient? Elicit an understanding that this knowledge is important in deciding a course of treatment.

› **Assessment ideas:** Ask learners to write the shortest paragraph possible using all of the following key terms: dichotomous, choice, decision, option, exclude. This is a good way to focus learners on developing their higher-order thinking skills. It helps them to make sense of the meaning of the terms, rather than simply recall them. To scaffold this activity for some learners, provide the first and final sentences, or reduce the number of words that they are expected to use.

3 The DNA clock (40 minutes)

Learning intention: Learners explore how organisms can be classified into groups by the features that they share, including their DNA sequence.

Resources: Photocopies of a photograph of an organism that is immediately recognisable (e.g. zebra). You need a photocopy for each member of the class. Importantly, the photocopies should be sequential: the first photocopy is of the original image; the second photocopy is of the first photocopy and so on until the final photocopy is barely recognisable as a zebra because the image has faded (ideally, it looks like a horse because the stripes are no longer clear).

Description and purpose: Give learners five minutes to determine the order in which the photocopies were made. Once they have completed this, hold a class discussion to elicit an understanding that this models the way in which DNA changes (mutates) over time from one sequence (image) into another. With a brief reference to DNA and its bases, elicit an understanding that we can determine the relationship between individuals by studying the sequence similarity.

Differentiation ideas:

Support – Provide pairs of learners with five sheets of paper that each contain a DNA sequence of 10–20 bases in length. Ask learners to decide the order of similarity with a sixth sequence that you provide.

Challenge – In the Workbook, Exercise 1.2: The biological classification system and Exercise 1.3: Keys provide learners with opportunities to extend the skills they have developed in this lesson.

Assessment ideas: Write a short guide for a younger learner to explain how DNA sequences can be used to help decide on relationships between organisms. This could be accompanied by a tangible example such as the development of different limb bone formations in mammals.

Plenary ideas

1 Summary questions (10 minutes)

Resources: Coursebook

Description and purpose: Exam-style questions 3 and 6 can be set as a summary of the key terms and concepts covered in this lesson.

2 Self-reflection (5 minutes)

Description and purpose: Give learners the opportunity to reflect on their experiences during this lesson to identify 'what went well' and 'even better if'. An alternative is the 'two stars and a wish' approach to encourage learners to reflect on each other's progress, by identifying two points of positive feedback and one point of constructive criticism.

Homework ideas

1 Spot the mistake

Prepare a written text that summarises the concepts that learners have studied in this subtopic and those previously. Include five to ten spelling mistakes and conceptual errors such as:

- Two members of different species will be able to produce fertile offspring.
- The binomial name of humans is homo Sapiens.
- Organisms with DNA base sequences that are very similar are very distantly related.

Encourage learners to spot and circle as many mistakes as possible, and offer corrections. This activity could be made into a competition, with the first learner who identifies all the mistakes is the winner.

2 Consolidation worksheet

Worksheet 1.1 provides an opportunity to reinforce some of the concepts and terms introduced during this lesson.

If time is short for learners to conduct their homework, provide learners with Homework exercise 1. However, to provide learners with a more comprehensive summary exercise regarding the importance of classification, choose Homework exercise 2.

1.3: Features of organisms

LEARNING PLAN

Syllabus learning objectives	Learning intentions	Success criteria
Core: State the main features used to place animals and plants into the appropriate kingdoms. State the main features used to place organisms into groups within the animal kingdom, limited to: • the main groups of vertebrates: mammals, birds, reptiles, amphibians, fish • the main groups of arthropods: myriapods, insects, arachnids, crustaceans. Classify organisms using the features identified above. **Supplement:** › State the main features used to place all organisms into one of the five kingdoms: animal, plant, fungus, prokaryote, protoctist. › State the main features used to place organisms into groups within the plant kingdom, limited to ferns and flowering plants (dicotyledons and monocotyledons). › Classify organisms using the features identified above. › State the features of viruses, limited to a protein coat and genetic material.	In this topic, learners will: • practise using and constructing keys › describe the features of the five kingdoms of organisms • describe how to classify vertebrates and arthropods › describe how to classify ferns and flowering plants › outline the features of viruses.	Learners will be able to determine the classification of a species based on its features.

Common misconceptions

Misconception	How to identify	How to overcome
Perhaps because they both start with the letter 'p', learners easily confuse prokaryotes and protoctists (including the example of *Plasmodium*).	Ask learners to produce a table or Venn diagram to compare the main features of organisms that belong to these kingdoms.	Provide a clear list of features that the organisms belonging to these kingdoms share and do not share.
Learners often refer to 'animals and birds', forgetting that birds are animals.	Tell learners that birds are animals. Is this true or false?	Help learners who answered 'false' to understand why birds belong to the animal kingdom.
Learners sometimes assume that all animals are mammals, and/or that humans are not animals.	Ask learners to describe what they think an animal is.	Tell learners that they may be surprised, but jellyfish, spiders and earthworms are just as much an 'animal' as a cat or a dog!
Learners often assume that animals and plants are the only classes of organisms, assuming that fungi are plants and overlooking microorganisms.	The second starter activity (learners decide which features are unique to animals and plants) can help correct this misconception.	Keep a list of the five animal kingdoms written clearly on the board, so that learners begin to get used to the idea that life on Earth consists of more than just animals and plants.
Learners may think that viruses are living and deserve their own kingdom.	Ask learners to rank the size of organisms – they may put viruses on the bottom of the hierarchy.	Refer learners back to their work on the characteristics of life and point out that viruses do not satisfy these features. You could also take this opportunity to inform learners that viruses are not cellular.

Starter ideas

1 Refreshing cell knowledge (10 minutes)

Resources: Learners need a pencil and an eraser. Provide a piece of A3 paper to each learner.

Description and purpose: Ask learners to draw a plant cell on one side of the paper, and an animal cell on the other. Ask learners to hold up their diagrams when you count to three. Spend a minute or so formatively assessing their prior knowledge by walking around the class and commenting on some of the diagrams you see. For example, are the plant cells roughly rectangular in shape? Do they have more components compared to the animal cell (cell wall, chloroplasts and a vacuole) and so on? Next, challenge learners to use their pencil, and eraser if necessary, to convert either their animal or plant cell into a bacterium, and the same for a protoctist. Most learners will be unsure what to do, so walk around and provide clues ('erase the nucleus' or 'add a long tail to the plant cell'). Gradually elicit that there are other kingdoms of organisms that learners may not have encountered before.

What to do next: Ask learners to write down the school's address and their home address next to each other. Elicit an understanding that the largest 'domain' – the country of the school and their home – is called a 'kingdom'. The smallest domain, the number of their house or school, is the species. Give a brief introduction to the hierarchy of life; however, point out the differences, such as the fact that the hierarchy of life is inverted compared to an address, with the largest domain at the top.

2 New kingdoms (10 minutes)

Description and purpose: Learners engage in a 'think, pair, share' activity to decide which features apply to animals and plants. When they have run out of ideas, provide a few more (the Coursebook provides a large number of characteristics). Then, when all learners are ready to move on, ask them to decide which of the characteristics they have recorded could also be applied to fungi, protoctists and bacteria. The aim is to highlight to learners that there are other kingdoms of organisms that they may not have encountered before.

What to do next: Hold a brief round of closed 'true/false' statements aimed at refreshing learners' prior knowledge regarding cell structure.

Main teaching ideas

1 Classification winning cards (50 minutes)

Learning intention: Learners explore the features of organisms that enable us to assign them to the five kingdoms of life.

Resources: Sheets of card that can be cut into small pieces (20 × 20 cm approx.).

Description and purpose: Using the internet or textbooks, provide an opportunity for each learner to research one vertebrate (choose from mammals, birds, reptiles, amphibians, fish) and one arthropod (choose from myriapods, insects, arachnids, crustaceans). Move round the room to ensure that different learners find out information about different organisms. Each learner should prepare two cards: one for each animal that lists its key features. Consider providing a list of key words on the board, to ensure consistency across the class. Photocopy the cards and provide pairs of learners with a pile of vertebrate cards and a pile of arthropod cards. The learners then lay them on the table two at a time, and compare the features: Which one has the most legs? Which one is largest? Which one reproduces more rapidly? This is a very effective way to help learners recognise the differences between vertebrates and arthropods. This idea can be adapted for comparing monocotyledons and dicotyledons. You can make a record of this activity by photocopying the images and providing a full set to learners as a handout. You may wish to model how to play the game with a volunteer from the class in full view before starting the game.

› Differentiation ideas:

Support – Provide the information in this topic in the form of tables where information can be recorded as ticks/crosses and short entries. This can help learners to see the similarities and differences between the domains and also between the eukaryotic kingdoms.

Challenge – The two protoctists in Figure 1.16 of the Coursebook could be used as the basis for a deeper discussion. Some learners might ask why *Paramecium*, which has animal-like features, and *Chlamydomonas*, which shares features with plants, are not described as unicellular animal and plant cells.

› Assessment ideas: Use three or four questions, ideally multiple-choice or short-answer questions, which learners complete and pass to you as they leave the room. One of these could be taken from the Coursebook (exam-style question 7). This 'exit card' technique can provide an opportunity for formative assessment, enabling you to judge whether or not reinforcement of the content of this lesson is necessary in the next lesson.

2 Comparing creatures (50 minutes)

Learning intention: Learners explore the features of organisms that enable us to assign them to the five kingdoms of life.

Description and purpose: Many learners can benefit from a very visual means of describing differences. Poster presentations, produced by groups of scientists, are an important way of conveying information at scientific conferences. Ask learners working in groups to prepare Venn diagrams or tables on posters that visually compare the features of the five kingdoms of life or groups of organisms occupying different phyla within those kingdoms. The posters should be highly visual, including diagrams, photographs (if a printer is available) and text. These can be prepared on a large piece of paper or card with a range of materials. Then hold a 'marketplace' activity in which one member of each group stands by their poster and offers an explanation to other groups as they move around the room. Learners should use the Coursebook, which comprehensively lists how to distinguish between the different organisms. Activity 1.4 in the Coursebook, Classifying animals, provides a similar activity.

› **Differentiation ideas:**

Support – Provide learners with an opportunity to seek support. This can be done by producing a series of 'clue cards', available on request. If a learner feels they need support, they can request a card from you. Each card provides a 'hint' that is intended to give the learner just enough information to help them move on with their work (e.g. 'Focus your comparison on the veins in leaves and the number of sections in the flowers' or 'Have you considered the number of antennae?').

Challenge – Extend the discussion with learners to consider the broader characteristics that differ between monocotyledons and dicotyledons (e.g. root systems, number of petals).

› **Assessment ideas:** Learners identify the 'odd one out' in a series of terms. For example, the odd one out in the series 'shark, dolphin, whale' is the shark, because it is a fish and the others are mammals.

3 Imaginary organisms (30 minutes)

Learning intention: Learners encounter the features of organisms that enable us to assign them to the five kingdoms of life.

Description and purpose: Allow learners to draw a number of imaginary organisms – examples may include a dragon, a unicorn, a griffin – to emphasise the features that they have in common with actual organisms. This could also include imaginary plants such as the triffid. They should compare their drawings with a partner and judge whether the features they have included are sufficient for their classification to be accurate.

› **Differentiation ideas:**

Support – Providing 'mind hooks' can be of great benefit to some learners. These can help learners remember key features of certain phyla (dicotyledons have two (di-) cotyledons, and mammals have mammary glands). They can also help learners recall the names and order of the taxa in the hierarchy of life (for example, 'King Philip Came Over From Great Spain').

Challenge – Encourage thinking among learners by challenging them to ask the question 'why?'. For example, 'Why is an exoskeleton an advantage over a backbone?' (and the opposite) and, 'Why is having many jointed legs (myriapods) an advantage over having few?'

› **Assessment ideas:** Display a wide variety of the key terms which learners know from the previous lesson on the board. As you call out a word, ask for a show of hands to see who feels confident in recalling its meaning, and then tell learners to keep their hand raised if they would like to offer a description.

CONTRIBUTED TEACHER ACTIVITY

Teacher name: ???????

Title: Classes of vertebrates

Timing: 20–30 minutes

Learning intention: This activity ensures that learners can differentiate between the different classes of vertebrates using their characteristics.

Resources: For each group:

- five copies of the list of characteristics and example animals
- one copy of a realistic image of each of the animals representing the different vertebrate classes, each on a piece of paper that is large enough to stick various characteristics on (e.g. Birds – a dove; Mammals – a lion; Amphibians – a frog; Fish – a clown fish; Reptiles – a turtle)
- scissors and glue.

Description: This activity can be done in pairs or groups of three. For each class of vertebrate, learners cut up a list of characteristics and choose the relevant characteristics for that class to stick onto the picture. They can also add any other animal they think belongs in that class.

Some characteristics may be used for more than one vertebrate class, some may not be used at all.

Differentiation: As the teacher, you can add or remove characteristics to make it easier for the less confident students.

You can ask students to design a similar activity for the classes of arthropods or to differentiate between the monocotyledons and dicotyledons.

CONTINUED

› Reflection opportunity: Ask learners to think about and discuss how the various characteristics fit into the way of life of each animal.

You can ask more confident learners how they think the characteristics could be used to make a dichotomous key.

Learners enjoy this activity. By the end of the activity, they feel more confident that they know the different traits and characteristics that are useful for classification. This makes differentiation easier in future exercises.

??????

Plenary ideas

1 Key word reinforcement (10 minutes)

Description and purpose: Encourage learners to ask 'What's the question?' when given an answer. Select a range of single-word terms and simple sentences related to this, for which learners need to construct questions. Examples include:

- '*arthropod*' (the question would require learners to understand that this is a phylum of the animal kingdom, with classes including insects, crustaceans, arachnids and myriapods)
- '*because it has hair*' (the question would require learners to know that mammals have this feature).

2 Guess the taxon (10 minutes)

Description and purpose: Display or draw a large picture of an organism which has been obscured by 12–15 small numbered 'jigsaw' pieces (this can be done virtually with computer software, or by affixing A3 sheets to the whiteboard). Learners are asked to choose which pieces to remove, thus gradually revealing the image, and to identify parts of the organism, whose kingdom, phylum and class they must identify. To add extra challenges to this activity, the learners who identify the features are then asked to choose another learner to identify which other organisms share each feature. This could form the basis of a competition, with the class divided into two teams. Have two or three examples of organisms ready, just in case learners guess the phylum very early.

3 Classification bingo (10 minutes)

Resources: Coursebook

Description and purpose: Challenge learners to a game of 'bingo' to consolidate the key terms that have been encountered in the previous subtopics. Provide each learner with a grid of nine squares. Then provide 20 key terms on the board, taken from the subtopics previously encountered. Learners select nine words at random to fill in the grid. Then call out definitions of each of the 20 key terms in random order. The first learner to tick off their nine words calls 'bingo' and wins the contest. For your reference during this activity, key terms in Chapter 1 of the Coursebook have definitions listed in the Glossary and the main text.

Homework ideas

1 Putting theory into practice

Encourage learners to collect leaves from plants that grow in your school's host country (be aware of poisonous varieties, and provide leaves yourself if there is a risk). Challenge them to classify them as monocotyledons, dicotyledons or ferns, and construct a key in their exercise books onto which the leaves are attached with sticky tape in a 'living library'. If you live in a region with high biodiversity, learners may explore the school grounds and 'tick off' as many of the groups of animals as they can spot in an activity called 'I spy'. Can they find the main groups of vertebrates: mammals, birds, reptiles, amphibians and fish? And what about the main groups of arthropods: myriapods, insects, arachnids and crustaceans?

2 Summary questions

Exam-style questions 2, 4 and 7–9 provide learners with an opportunity to apply their knowledge of the key features of different phyla. Workbook Exercises 1.6–1.9 provide further opportunities to reinforce this content.

If learners have found the classification of plants most difficult, Homework exercise 1 should be chosen. However, if learners have found distinguishing between the different phyla of animals more challenging, then choose Homework exercise 2.

Links to digital resources

- www.cambridge.org/links/bctd7001 offers a clip that explains the binomial system of classification.
- Access this Coggle diagram to further explore the reasons why classification of organisms is important: www.cambridge.org/links/bctd7002
- This website provides an opportunity to extend learners' understanding through reading a relevant article on the use of DNA base sequences to understand the relationship between butterflies: www.cambridge.org/links/bctd7003

CROSS-CURRICULAR LINKS

Link the topics learners encounter in this chapter with the curricula of other subjects and collaborate with other teachers from other departments in your school. For example:

- Compare the organisation of living organisms into hierarchical groups with the organisation of locations in geography (countries, states, towns and place names) and elements into groups in the periodic table.
- Find examples of mistakes that were made during the development of taxonomy, before scientists knew all of the features of different groups of organisms.
- There are many opportunities in this chapter for learners to practise their drawing skills, for example of parts of organisms used to classify them.

With regard to the rest of their Biology course, encourage learners to consider how their study of this topic is important in topics such as inheritance (Chapter 16).

Project guidance

A new species

- To prepare the class for the Project, identify a number of internet sites that would be useful for learners during their research. Inform learners of the relative pros and cons of the different options that they could select from to present their work, including as an illustrated talk, or in the form of a poster.
- During the project, provide roles to learners during the group work to ensure that all members are engaged. Roles could include the decision maker, the scribe and the internet researcher. This can also be used to differentiate learning: provide a more challenging role for a more confident learner (answering the final question in the project details, for example).
- To assess the work that learners produce, provide the opportunity to 'showcase' their work. This could be in the form of a ten-minute poster marketplace, where one member of each group remains with their poster to explain its contents to other groups as they circulate. Alternatively, short presentations could be given, with learners in the audience encouraged to actively listen: give them a checklist to complete, or challenge them to think of one question to ask at the end of each talk (choose a learner at random). Provide feedback on their work, and emphasise in your comments that the most successful submissions are those that cover the content of the syllabus, but which use new examples of animals and plants that are unfamiliar to other members of the class. Give credit to learners who are able to speak fluently about their work and answer other learners' questions with confidence.

Differentiation worksheet packs (downloadable)

Two worksheets of questions on classification for different abilities.

If learners find it difficult to explain the importance and application of classification, they would find Worksheet 1 most appropriate.

Worksheet 2 has slightly more difficult tasks, which also involve comparing the features of different groups of animals. More confident learners should choose this worksheet, which has an extra-stretch sheet that extends thinking.

1 The application of classification

Structured worksheet split into three levelled sections covering a range of learner abilities on the source of taxol and the usefulness of taxonomy.

2 Exploring relationships

Worksheet on the relationships between birds with a help sheet and an extra-stretch sheet to meet the demands of a range of learners of differing abilities.

Practical Workbook guidance

Chapter 1: Characteristics and classification of living organisms

Practical investigation 1.1: Construct a dichotomous key

Planning and setting up the investigation

This depends upon your own school environment. You may be able to take learners outside into the school grounds and look for different leaves. If preferred, it may be more time-friendly to obtain different types of leaves yourself, in advance. Some schools may have suitable invertebrates available, in which case an insect pooter may be provided. Care should be taken to return any organisms used to their natural habitat.

Safety

This is a low-risk investigation, but learners should wash their hands afterwards if handling plants, soil, or invertebrates. Gloves may also be provided. You should set clear boundaries about which parts of the school grounds are accessible.

Common errors to be aware of

Learners may have been exposed to incorrect use of the term 'microorganism' from previous learning. Ensure that learners do not use this term, or other similar informal terms such as 'beasties' or 'bugs'. Some learners will wish to shade or colour their diagrams, so the importance of a clear biological diagram should be reinforced.

Differentiation

Some learners will struggle to draw clear diagrams at first. Demonstrate how to make a clear, labelled drawing on the board and allow learners to come up and attempt on the board before committing to their workbooks. This could involve asking those learners that are excellent at drawing to demonstrate their skills, or simply allowing learners to draw with freedom on the board.

Discussion points and scientific explanation

Select different keys to ask learners to compare. Encourage them to identify what makes a good key, and how other keys should be improved. Further discussion can lead to what scientists do next; how scientists can establish the relationships between the observable characteristics, by using DNA and establishing evolutionary relationships.

Exemplar data

Chapter 2: Cells

Practical investigation 2.1: Observing plant cells

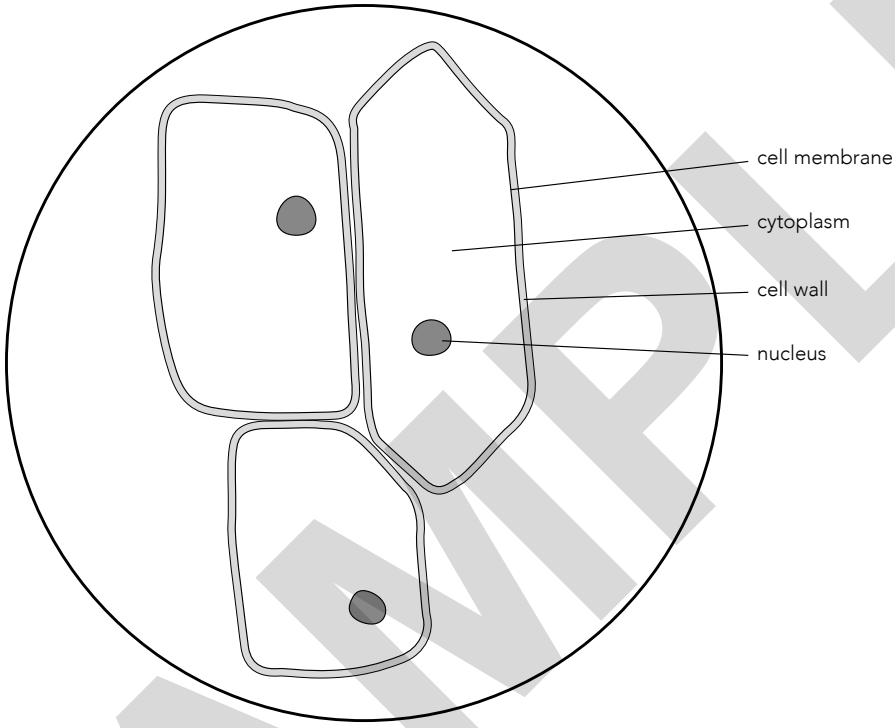

Figure 2.1: Plant cells viewed under a microscope.

*Please note, Exemplar data from Chapter two has been used in this sample.

Practical investigation 2.2: Observing animal cells

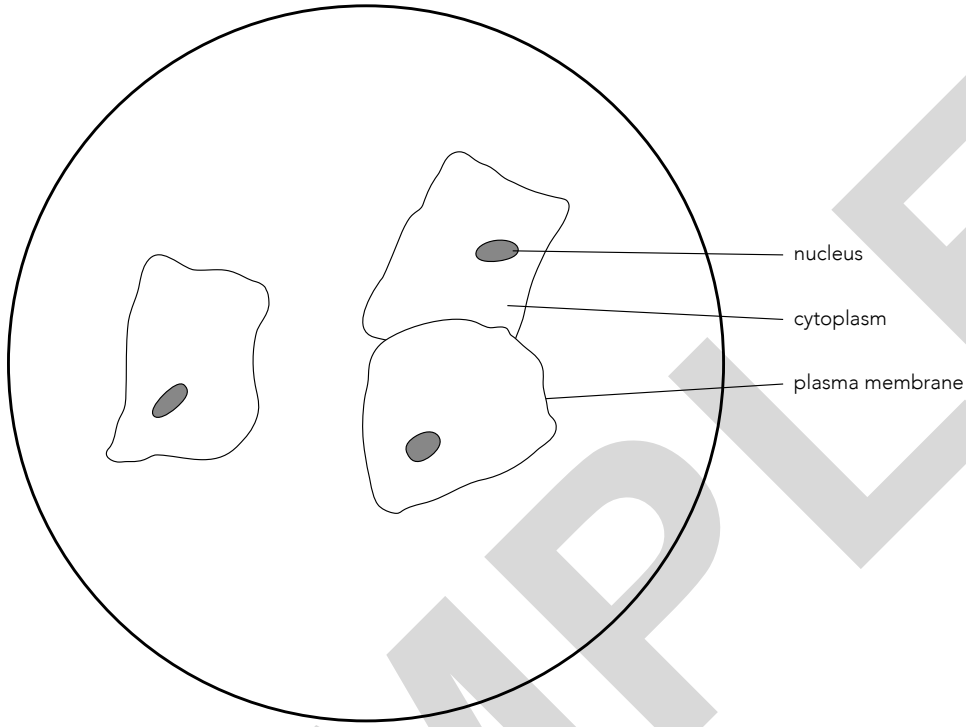

Figure 2.2: Animal cells viewed under a microscope.

Practical investigation 2.3: Drawing biological specimens

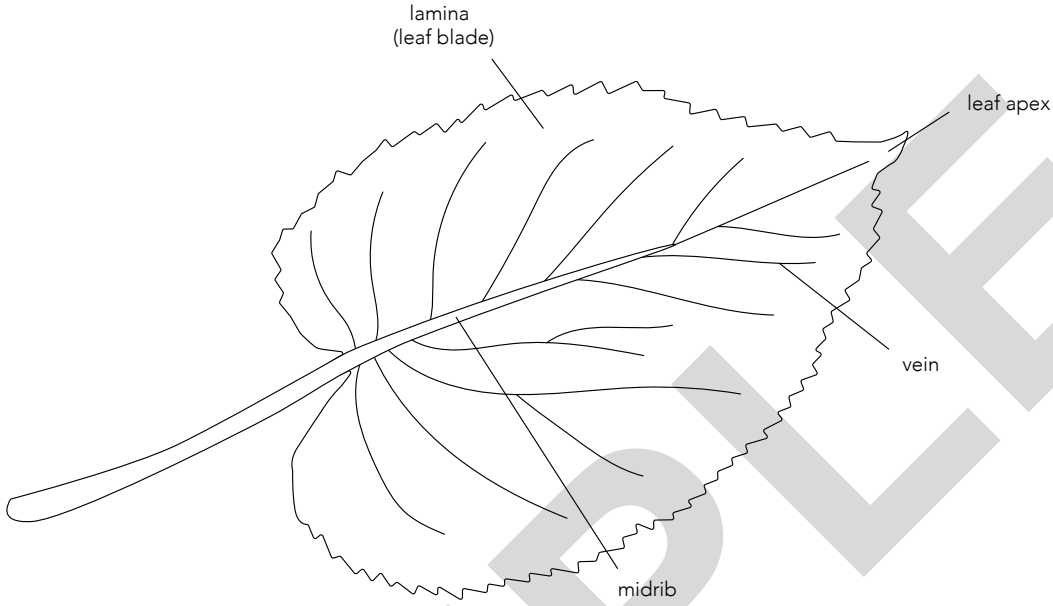

Figure 2.3: Student drawings of chosen organisms.

We are working with Cambridge Assessment International Education towards endorsement of this title.

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Biology

for Cambridge IGCSE™

WORKBOOK

Mary Jones & Geoff Jones

Fourth edition

Digital Access

Cambridge Assessment International Education

Endorsed for learner support

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How to use this book

Throughout this book, you will notice lots of different features that will help your learning. These are explained below. Answers are accessible to teachers for free on the 'supporting resources' area of the Cambridge GO website.

KEY WORDS

Definitions for useful vocabulary are given at the start of each section. You will also find definitions for these words in the Glossary at the back of this book.

Supplement content: In the key word boxes, Supplement content is indicated with a large arrow, as in this example.

LEARNING INTENTIONS

These set the scene for each exercise, beginning with 'In this exercise you will:', and indicate the important concepts.

In the learning intentions box, Supplement content is indicated with a large arrow and a darker background, as in this example.

TIPS

The information in these boxes will help you complete the exercises, and give you support in areas that you might find difficult.

Exercises

These help you to practise skills that are important for studying IGCSE Biology.

Questions within exercises fall into one of three types:

- Focus questions will help build your basic skills.
- Practice questions provide more opportunities for practice, pushing your skills further.
- Challenge questions will stretch and challenge you even further.

SELF/PEER ASSESSMENT

At the end of some exercises, you will find opportunities to help you assess your own work, or that of your classmates, and consider how you can improve the way you learn.

Supplement content

Where content is intended for students who are studying the Supplement content of the syllabus as well as the Core, this is indicated with the arrow and the bar, as you can see on the left here.

Chapter 1

Characteristics and classification of living organisms

Characteristics of living organisms

KEY WORDS

excretion: the removal of the waste products of metabolism and substances in excess of requirements

growth: a permanent increase in size and dry mass

metabolic reactions: chemical reactions that take place in living organisms

movement: an action by an organism or part of an organism causing a change of position or place

nutrition: taking in materials for energy, growth and development

organism: a living thing

reproduction: the processes that make more of the same kind of organism

respiration: the chemical reactions in cells that break down nutrient molecules and release energy for metabolism

sensitivity: the ability to detect and respond to changes in the internal or external environment

Exercise 1.1

IN THIS EXERCISE YOU WILL:

practise naming and describing the characteristics of living things.

Focus

1 Draw lines to match each term with its description.

Term	Description
nutrition	making more of the same kind of organism
respiration	removing waste products of metabolism
growth	a permanent increase in size and dry mass
excretion	taking in materials for energy, growth and development
reproduction	chemical reactions that release energy from nutrient molecules

Practice

2 Figure 1.1 shows a plant, growing towards the light. Inside its leaves, photosynthesis is taking place. Photosynthesis uses carbon dioxide to make glucose, and releases oxygen.

Add labels to Figure 1.1. Your labels should include short descriptions stating how the plant is showing these characteristics of living things:

- reproduction
- growth
- sensitivity
- excretion

Figure 1.1: A plant growing towards the light.

Challenge

3 Imagine that someone from another planet is visiting Earth. They see aeroplanes and birds moving through the sky.

Explain to the visitor why birds are alive and aeroplanes are not alive, even though they seem to share some of the characteristics of living things.

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The biological classification system

KEY WORDS

binomial system: a system of naming species that is internationally agreed, in which the scientific name is made up of two parts showing the genus and the species

fertile: able to reproduce

genus: a group of species that share similar features and a common ancestor

species: a group of organisms that can reproduce to produce fertile offspring

Exercise 1.2

IN THIS EXERCISE YOU WILL:

- check that you know what a binomial is
- practise finding evidence in a short, written passage
- think about advantages of using the binomial system.

Focus

4 Complete the sentences, using words from the list.

binomial **biological** **complete** **fertile** **genus** **group** **healthy** **living** **population** **reproduce** **species**

An organism is a ..... thing. A ..... is a group of living organisms that can ..... with each other to produce ..... offspring.

Each species of organism has a two-word name. This system of naming is called the ..... system. The first of the two words in the name tells us the ..... that the species belongs to.

Practice

5 Tigers, *Panthera tigris*, and lions, *Panthera leo*, sometimes mate with each other if they are kept together in a zoo. The offspring are called ligers. Ligers are perfectly healthy, but are unable to reproduce.

Use this information to write down:

a *one* piece of evidence that lions and tigers are closely related

.....

.....

b *two* pieces of evidence that lions and tigers belong to different species.

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Challenge

6 Many people dislike using binomials for species. They would prefer to just use English names.

Explain why it is helpful to scientists to use the binomial system.

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Keys

KEY WORDS

dichotomous key: a way of identifying an organism, by working through pairs of statements that lead you to its name

Exercise 1.3: Focus

IN THIS EXERCISE YOU WILL:

practise using a key to identify four animals.

7 Figure 1.2 shows four vertebrates.

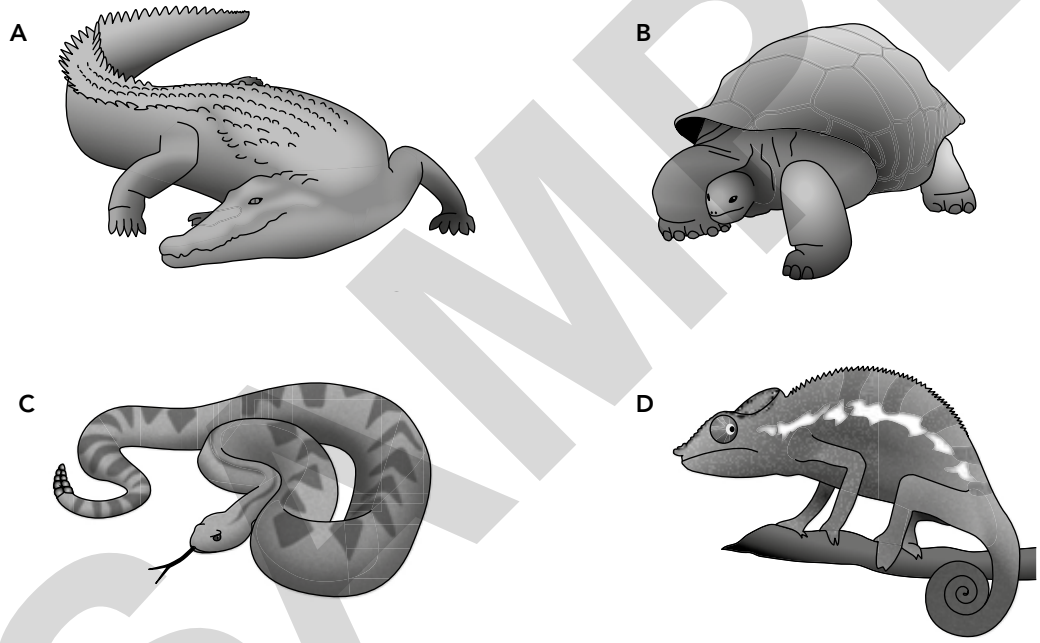

Figure 1.2: Four vertebrates.

Use the dichotomous key to identify each of these four animals.

List the sequence of statements that you worked through to find the name.

TIP

Remember to work on one animal at a time. Identify that one, then move on to the next.

1	**a**	shell present	*Geochelone elephantopus*
	b	shell absent	go to **2**
2	**a**	four legs	go to **3**
	b	no legs	*Ophiophagus hannah*
3	**a**	back and tail are covered with rough spikes	*Crocodylus niloticus*
	b	no spikes on tail	*Chamaeleo gracilis*

TIP

When writing binomials, underline them to show that they should be in italics. Remember that the genus name starts with a capital letter but the species name is all lowercase.

Animal A has been done for you.

A 1b, 2a, 3a – Crocodylus niloticus

B .....

C .....

D .....

Exercise 1.4: Practice

IN THIS EXERCISE YOU WILL:

practise writing a dichotomous key by completing one that has already been started.

8 Figure 1.3 shows a spider, locust, centipede and crab.

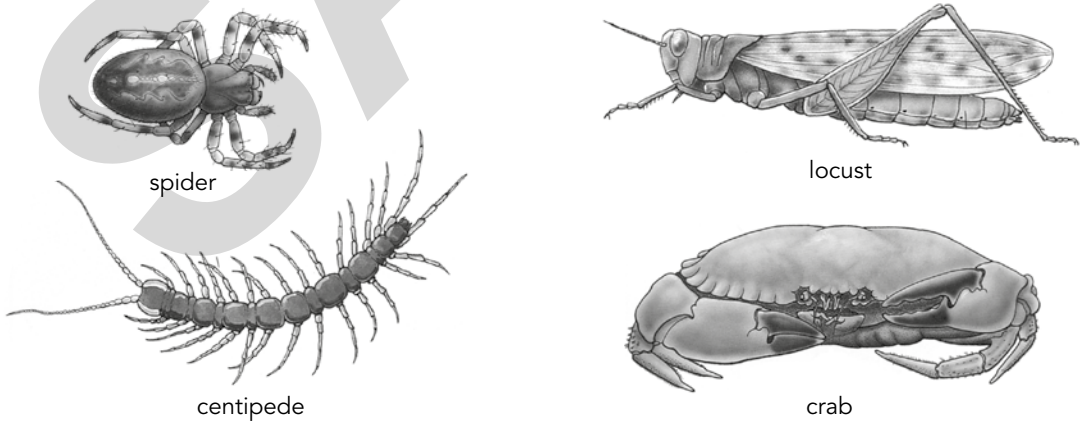

Figure 1.3: Spider, locust, centipede and crab.

Here is the start of a key to help someone who does not know anything about these animals to identify them. Complete the key by writing more pairs of statements.

Then try your key out on a friend.

1 **a** has antennae ..... go to **2**

b does not have antennae ..... spider

2 **a** has three pairs of legs .....

b .....

3 **a** .....

b .....

Exercise 1.5: Challenge

IN THIS EXERCISE YOU WILL:

write your own dichotomous key.

9 Figure 1.4 shows photographs of four species of fish.

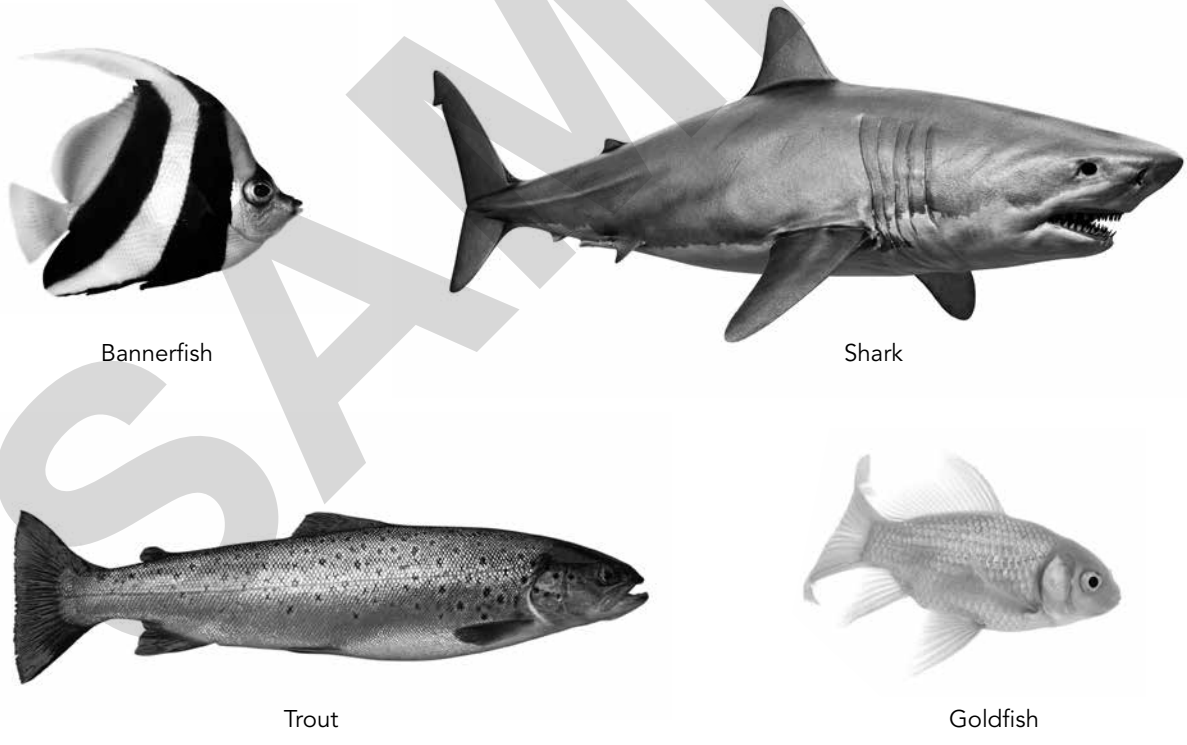

Figure 1.4: Four species of fish.

Write a dichotomous key to enable someone to identify each of the four fish.

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SELF-ASSESSMENT

How confident do you feel about using and writing keys? Rate yourself for each of the points in the checklist using:

☺ if you did it really well

😐 if you made a good attempt at it and partly succeeded

☹ if you did not try to do it, or did not succeed

Checklist	Rating
I can use a dichotomous key to identify organisms.	
I can complete a key that has already been started.	
I can write my own key with no help.	

What will you do to improve your ability to write a good dichotomous key?

……

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……

Kingdoms

KEY WORDS

fungus: an organism whose cells have cell walls, but that does not photosynthesise

hyphae: microscopic threads, made of cells linked in a long line, that make up the body of a fungus

kingdom: one of the major groups into which all organisms are classified

spores: very small groups of cells surrounded by a protective wall, used in reproduction

Exercise 1.6

IN THIS EXERCISE YOU WILL:

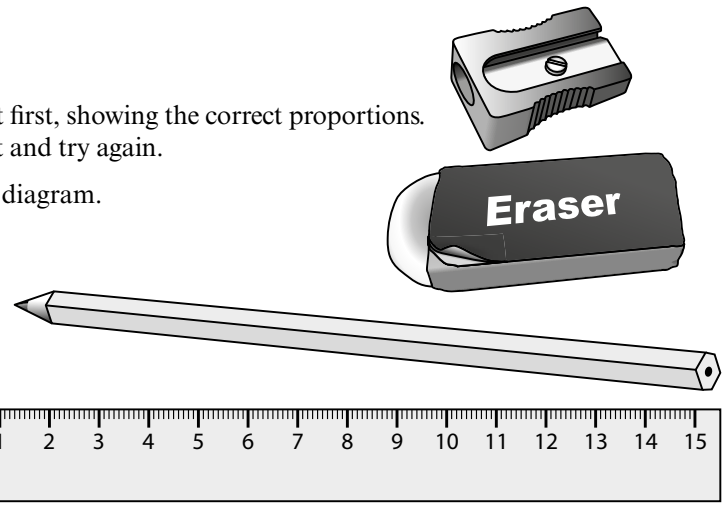
practise making the kind of drawing that is used in biology.

Biologists often need to describe clearly what they observe when studying organisms. One of the best ways to do this is to make a drawing.

A biological drawing needs to be simple, but clear. Sometimes, you need to label your drawing to indicate important features.

Here are some points to think about when you draw.

- Make good use of the space on your sheet of paper – your drawing should be large. However, do leave space around it so that you have room for labels.
- Always use a sharp HB pencil and have a good eraser with you.
- Keep all lines single and clear with no breaks.
- Do not use shading.
- Do not use colours.
- Take time to get the outline of your drawing correct first, showing the correct proportions. Do this lightly to start with, so that you can rub out and try again.

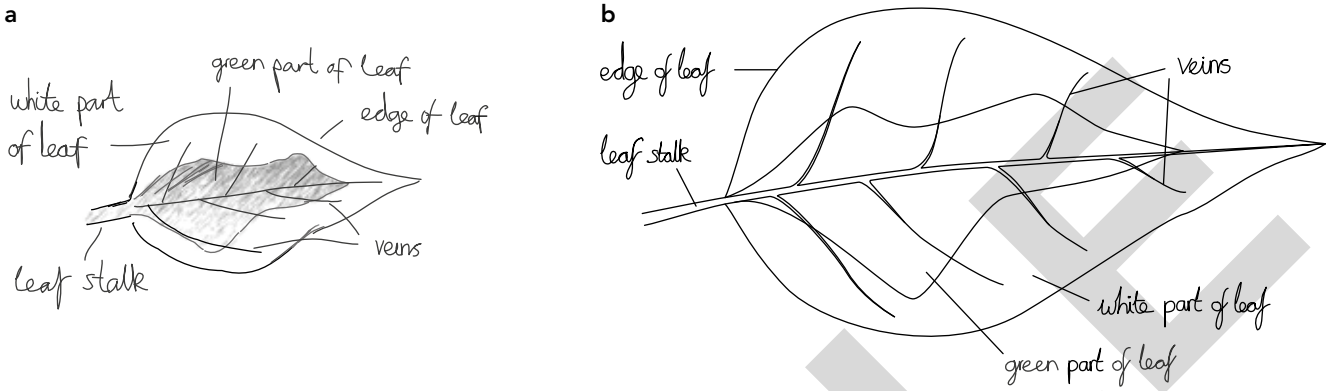


Here are some points to bear in mind when you label a diagram.

- Use a ruler to draw each label line.
- Make sure the end of the label line touches the structure being labelled.
- Write the labels horizontally.
- Keep the labels well away from the edges of your drawing.
- Do not let label lines cross one another.

Focus

Figure 1.5 shows two drawings of a leaf made by learners.



Figures 1.5 a and b: Two drawings of a leaf made by learners.

10 List *five* ways in which the second drawing (Figure 1.5b) is better than the first drawing (Figure 1.5a).

i .....

ii .....

iii .....

iv .....

v .....

Practice

11 Figure 1.6a is a photograph of an earthworm. A learner has begun to make a drawing of the earthworm (Figure 1.6b).

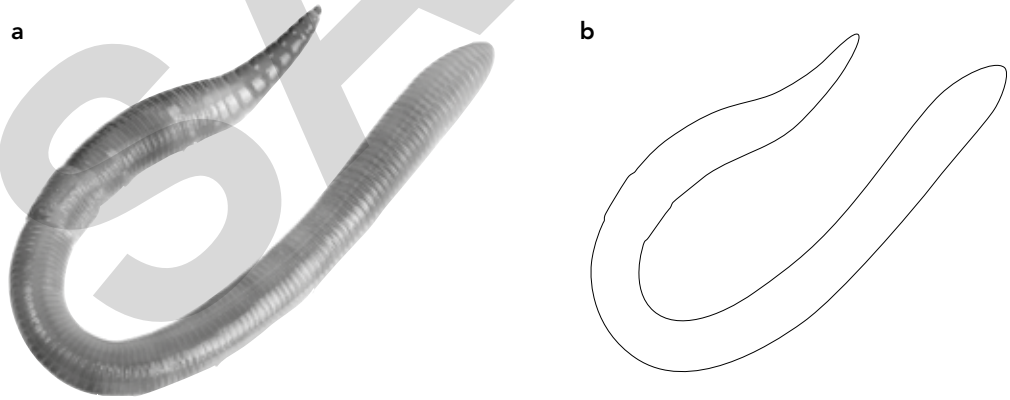


Figure 1.6 a: A photo of an earthworm. **b:** A drawing of the same earthworm.

a Complete the drawing of the earthworm. Add *two* labels to your drawing.

b Earthworms belong to the animal kingdom. Describe *two* features of an earthworm that you would *not* find in an organism belonging to the plant kingdom.

i .....

ii .....

Challenge

12 Figure 1.7 is a photograph of a fungus.

Figure 1.7: A fungus, *Amanita muscaria*.

a Draw a large diagram of the fungus in the space below. Do not label your diagram.

b Explain how organisms belonging to the fungus kingdom differ from those belonging to the plant kingdom.

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SELF-ASSESSMENT

How confident do you feel about making a good biological drawing? Rate yourself for each of the points in the checklist using:

Green if you did it really well

Amber if you made a good attempt at it and partly succeeded

Red if you did not try to do it, or did not succeed

Checklist	Colour
My drawing fills the space on the page, with enough room left for labels.	
I used a sharp pencil for the drawing.	
I did not use any shading or colours.	
All of the lines I drew are single and clear, with no breaks.	
The shape and proportions of my drawing are a good representation of the object.	

Groups within the animal and plant kingdoms

KEY WORDS

diaphragm: a muscle that separates the chest cavity from the abdominal cavity in mammals; it helps with breathing

dicotyledons: plants with two cotyledons in their seeds

exoskeleton: a supportive structure on the outside of the body

mammary glands: organs found only in mammals, which produce milk to feed young

metamorphosis: changing from a larva with one body form to an adult with a different body form

monocotyledons: plants with only one cotyledon in their seeds

pinna: a flap on the outside of the body that directs sound into the ear

placenta: an organ that connects the growing fetus to its mother, in which the blood of the fetus and mother are brought close together so that materials can be exchanged between them

Exercise 1.7: Focus

IN THIS EXERCISE YOU WILL:

check that you remember the characteristic features of the five groups of vertebrates.

Table 1.1 shows some features of five vertebrates.

Animal	What is its skin like?	Does it have wings?	Does it have a beak?	What are its eggs like?
A	smooth	no	no	soft, without a shell
B	has hair	yes	no	does not lay eggs
C	has feathers	yes	yes	with a hard shell
D	has scales	no	no	soft, without a shell
E	has hair	no	no	does not lay eggs

Table 1.1: Features of five vertebrates.

13 Identify the group of vertebrates to which each animal belongs.

A ……. **D** …….

B ……. **E** …….

C …….

14 Animals **B** and **E** belong to the same group.

List *two* features of these animals, other than those in the table, that are characteristic features of this group.

i …….

ii …….

15 Name *one* group of vertebrates that is *not* included in the table.

…….

Exercise 1.8: Practice

IN THIS EXERCISE YOU WILL:

practise remembering the characteristic features of the four groups of arthropods.

16 List *two* features that all arthropods share, that are *not* found in other groups in the animal kingdom.

i …….

ii …….

17 Complete the table to show the characteristic features of the four groups of arthropods.

Group	Number of pairs of legs	Number of pairs of antennae	Other distinguishing features, if any
arachnids			
insects			
myriapods			
crustaceans			

Exercise 1.9: Challenge

IN THIS EXERCISE YOU WILL:

practise remembering the characteristic features of ferns and flowering plants (monocotyledons and dicotyledons).

18 List *three* features shared by ferns and flowering plants, which are *not* shared by organisms in the animal or fungus kingdom.

i .....

ii .....

iii .....

19 Describe *two* ways in which ferns differ from flowering plants.

i .....

ii .....

20 Draw a table in the space below to summarise the characteristic features of monocotyledons and dicotyledons.

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Biology

for Cambridge IGCSE™

PRACTICAL WORKBOOK

Matthew Broderick

Fourth edition

Digital Access

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How to use this book

Throughout this book, you will notice lots of different features that will help your learning. These are explained below. Answers are accessible to teachers for free on the 'supporting resources' area of the Cambridge GO website.

INTRODUCTION

These set the scene for each chapter and indicate the important concepts. These start with the sentence 'The investigations in this chapter will:'.

KEY WORDS

Key vocabulary and definitions are given at the start of each investigation. You will also find definitions of these words in the Glossary at the back of this book.

COMMAND WORDS

Command words that appear in the syllabus and might be used in exams are highlighted in the exam-style questions. In the margin, you will find the Cambridge International definition. You will also find these definitions in the Glossary at the back of the book with some further explanation on the meaning of these words.

LEARNING INTENTIONS

These set out the learning intentions for each investigation.

The investigations include information on **equipment**, **safety considerations** and **method**. They also include **questions** to test your understanding on recording data, handling data, analysis and evaluation.

Remember that there is a **safety section** at the start of this book – you should refer to this often, as it contains general advice that is applicable to many of the investigations.

REFLECTION

These encourage you to reflect on your learning approaches.

TIPS

The information in these boxes will help you complete the questions, and give you support in areas that you might find difficult.

Supplement content

Where content is intended for students who are studying the Supplement content of the syllabus as well as the Core, this is indicated using the arrow and the bar, as on the left here.

EXAM-STYLE QUESTIONS

Questions at the end of each chapter provide more demanding exam-style questions, some of which may require use of knowledge from previous chapters. The answers to these questions are accessible to teachers for free on the Cambridge GO site.

Note for teachers:

The Teacher's Resource in this series includes sample data and support notes for each of the practical investigations in this practical workbook. You can find information about planning and setting up each investigation, further safety guidance, common errors to be aware of, differentiation ideas and additional areas for discussion.

Answers to all questions in this practical workbook are also accessible to teachers at www.cambridge.org/go

Chapter 1

Characteristics and classification of living organisms

THE INVESTIGATION IN THIS CHAPTER WILL:

- review the main characteristics of different organisms
- help you to construct a dichotomous key
- enable you to practise your biological drawing skills
- help you to identify different groups of organisms based on the organisms' external features.

Practical investigation 1.1: Construct a dichotomous key

KEY WORDS

biological drawing: used to represent the visible features of an organism, in the correct size, shape and proportion

dichotomous key: a way of identifying an organism, by working through pairs of statements that lead you to its name

feature: parts of an organism that you can see; also known as characteristics, e.g. the fur of a mammal

magnification: how many times larger an image is than the actual object. If an object is drawn smaller than its actual size, then the magnification is less than 1.

IN THIS INVESTIGATION YOU WILL:

- construct a dichotomous key that is relevant to your local area
- make a biological drawing and use the drawing to identify an organism.

YOU WILL NEED:

- range of specimens of leaves (provided for you)
- paper and pencil
- if collecting organisms yourself: any other items, such as, small tray / box / container, forceps / tweezers, latex gloves, insect pooters, etc. Your teacher will provide these dependent on your local environment.

Safety

- Ensure that the leaves are free from other organisms.
- Wash your hands after handling any organisms.
- Think about the safety requirements for *your* chosen environment. What do you need to look out for, or be aware of?

Getting started

Think about the main features of the organisms that you are looking at. What should you be looking for? For example, when you are looking for suitable specimens, you might choose to consider the different structure of leaves.

Method

1 If you are collecting organisms yourself, gather the equipment required (if you are collecting invertebrates then you may require equipment such as a pooter). Otherwise, use the organisms provided for you by your teacher.

2 Search for, and collect, at least three organisms that have different features. Use the equipment provided that is most suitable for organisms that you intend to collect.

3 Return to the laboratory or classroom with your organisms. Identify the different features that might help you to put the organisms into different groups.

4 Draw a draft dichotomous key in the space below. You should begin by looking for features that might distinguish one organism from another. Try to keep your answers simple, using 'yes' and 'no'. Sometimes, this takes a bit of trial and error so use a pencil at first and do not be afraid to change your questions or answers at any point.

TIP

When constructing a dichotomous key, use the most obvious features that you can actually *see*.

5 When you have completed your key, work with a partner to test the key with your chosen organisms.

6 Once you are happy that your key works, you can construct your final dichotomous key and ask other people in the class to use it.

Recording data

1 Make a large drawing of one of your organisms in the space below. Label the drawing.

2 State the features of your organism that help you to identify which group the organism belongs to.

……

……

3 State the group that your organism belongs to.

……

Handling data

4 Use a ruler to measure the length of the actual organism. Then use the ruler to measure the length of your drawing of that organism. Use this information to calculate the magnification of your drawing.

……

……

……

TIP

Try to use millimetres as your unit of measurement as millimetres are much easier to convert into other units if required.

Remember, the magnification is the image size, divided by the actual size.

TIP

When you are finished, organisms should be returned back to their habitat to ensure they are not harmed and to limit the impact of the investigation.

Analysis

5 Analyse your drawing skills. How many of the skills below have you used when drawing your specimen? Tick the ones that you have used correctly. These are important skills when making a biological drawing.

Drawing skills	I have done this
I used a sharp pencil.	
I drew smooth, single lines.	
I drew the specimen in the correct shape and proportion.	
The drawing is larger than the actual specimen (where possible).	
I have drawn all observable features.	
I used a ruler to draw neat lines from the labels to the drawing. Each line touches the feature that the line identifies.	
I have not shaded the diagram, or used colours.	

Evaluation

6 Suggest why it is important you follow the 'rules' when making a biological drawing.

……..

……..

REFLECTION

Using the checklist above, how could you improve your biological drawings?

……..

……..

EXAM-STYLE QUESTIONS

1 The adult housefly (*Musca domestica*) is found in many countries around the world.

a Make a larger drawing of the adult housefly in the space provided. **[5]**

b Measure the actual size of the length of one of the wings in the figure.

..... **[1]**

c **Calculate** the magnification of the same wing on your drawing of the figure. Give your answer to three significant figures.

.....

.....

..... **[2]**

d **State** the binomial name of the adult housefly.

..... **[1]**

e **Identify** the features of the housefly that would place it in the insect group.

.....

..... **[2]**

[Total: 11]

COMMAND WORDS

calculate: work out from given facts, figures or information

state: express in clear terms

identify: name/ select/recognise

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Biology

for Cambridge IGCSE™

ENGLISH LANGUAGE SKILLS WORKBOOK

Matthew Broderick & Tim Chadwick

Fourth edition
Digital Access

Cambridge Assessment International Education

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How to use this book

Throughout this book, you will notice lots of different features that will help your learning. These are explained below.

INTRODUCTION

This sets the scene for each chapter.

LEARNING INTENTIONS

These set out the learning intentions for each exercise. Each exercise will help you to develop both your English skills and your biology skills.

KEY WORDS

Key vocabulary and definitions are given in boxes at the start of exercises. You will also find definitions of these words in the Glossary at the back of this book.

Exercises

These help you to develop and practise your English skills alongside your Biology skills.

LANGUAGE FOCUS

These give you more information about parts of the English language that you may find challenging, to help you use English more fluently.

LANGUAGE TIPS

The information in these boxes will help you complete the questions using correct English, and give you support in areas that you might find difficult.

Chapter 1

Characteristics and classification of living organisms

IN THIS CHAPTER YOU WILL:

Science skills:

- use the binomial naming system
- identify the characteristics of living organisms

English skills:

- write full sentences about different species and organisms.

Exercise 1.1 Characteristics of living organisms

KEY WORD

characteristic: a typical feature of something. A characteristic helps you identify something

IN THIS EXERCISE YOU WILL:

Science skills:

- identify the seven characteristics of living organisms

English skills:

- list the key words associated with living organisms.

All living organisms share the same seven characteristics of life. We do not consider them to be 'alive' if they do not have all seven. This exercise will help you identify the seven signs of life.

1 Look at the word search puzzle. Find and circle the names of the seven characteristics for living things. You will also find the scientific term for a living thing in the word search.

P	M	K	X	A	F	H	R	A	Z	E	O	P	V	W
N	S	O	O	T	T	Z	H	F	X	X	R	S	D	Z
X	V	O	V	W	M	L	L	P	F	F	G	D	U	D
U	Q	Y	O	E	Y	X	R	B	P	I	A	S	X	N
D	R	R	Y	N	M	O	Q	A	I	T	N	E	H	U
C	G	E	B	N	J	E	I	S	W	J	I	N	G	T
H	W	W	S	E	E	Z	N	H	K	I	S	S	K	R
K	S	J	E	P	O	S	Q	T	O	R	M	I	U	I
O	G	N	U	X	I	E	R	D	X	A	O	T	K	T
D	K	J	O	Q	N	R	P	K	P	D	N	I	S	I
D	O	X	Q	B	C	T	A	D	V	J	F	V	Z	O
R	E	P	R	O	D	U	C	T	I	O	N	I	Z	N
M	B	J	W	Q	I	P	B	P	I	F	Q	T	B	N
T	K	V	I	L	O	E	Z	M	H	O	L	Y	B	T
H	H	G	E	X	C	R	E	T	I	O	N	A	R	G

2 Complete the table by matching the eight words from the word search with their definition.

Definition	Word
a living thing	
an action by a living thing or by part of a living thing that causes a change of position or place	
the chemical reactions in cells that break down nutrient molecules and release energy	
the ability to detect and respond to changes in the environment	
a permanent increase in size	
processes that make more of the same kind of living thing	
the removal of the waste products	
taking in materials for energy, increase in size, and development	

Table 1.1: The seven characteristics of life.

Exercise 1.2 Constructing a key – writing opposites

KEY WORDS

dichotomous key: a key consisting of pairs of definitions used to identify an organism. When you choose the definition that matches your organism, you are led to the next choice. In the end, you get the name of your organism or the group it belongs to.

IN THIS EXERCISE YOU WILL:

Science skills:

- complete a dichotomous key

English skills:

- use opposites in sentences.

In this exercise you will develop the important skill of expressing opposites. This is essential when constructing a dichotomous key.

When you use a dichotomous key, you should be able to identify the species or organism you are observing. Each part of the key is written using statements that express opposites, so that you can decide if a particular characteristic is present or not. For example:

- The organism has jointed limbs.
- The organism does not have jointed limbs.

LANGUAGE FOCUS

The present simple

When we state facts that are always true, for example characteristics of organisms, we use the present simple. The present simple is easy to form: just use the verb, and remember to put the subject in front of the verb, not after it. For example:

Birds lay eggs. Fish live in water.

If the subject is the third person-singular (a bird, a fish, etc.), add '- *s*' or '- *es*' to the verb. For example:

A bird lays eggs. A fish lives in water.

With verbs ending with *-s*, *-z*, *-tch*, *-ch* or *-sh*, you need to add *-es*:

An eagle catches fish.

Have and *can* are irregular; look:

A bird has feathers.

A bird can fly.

To write the opposite sentence, we need the negative. Most verbs form the negative with *do/does + not:*

A fish does not have feathers. Birds do not have gills.

Be and *can* are a little irregular in the negative.

Fertilisation is not internal. There aren't any leaves.

The organism cannot fly.

3 Complete the dichotomous key. The first example has been done for you.

i The organism has fur.

The organism does not have fur.

ii The organism has feathers.

……..

iii The organism's skin is dry.

……..

iv The organism fertilises externally.

……..

v The organism has gills in adults.

……..

vi The organism can lay eggs.

……..

Exercise 1.3 Describing organisms

KEY WORDS

binomial: an adjective for a name with two words

homeotherm: an organism that can maintain a constant internal body temperature

phylum: the scientific word for a category below 'kingdom' and above 'class'

vertebrate: an organism that has a backbone/spinal cord, such as mammals, amphibians, birds, reptiles, and fish

IN THIS EXERCISE YOU WILL:

Science skills:

- identify key characteristics of birds

English skills:

- extract important information from a text or a diagram.

Birds are one of the main vertebrate groups in the animal kingdom. In this exercise you will learn some characteristics of birds. To do this, you will read a short text and look at a diagram. You will then extract key information from the text and the diagram. Finding information in a text or article is an important skill in biology.

4 Read the text and look at Figure 1.1. Then answer the questions.

LANGUAGE TIP

Use the phrase *such as* as another way of saying *for example*.

Birds such as the Brown falcon (*Falco berigora*) belong to the class *Aves* (birds) in the vertebrate phylum of the animal kingdom. Birds have lungs, feathers and beaks as common observable characteristics. Like humans, birds are required to maintain their internal body temperature and are considered to be homeotherms. Birds are similar to reptiles in that they can reproduce by internal fertilisation and lay eggs.

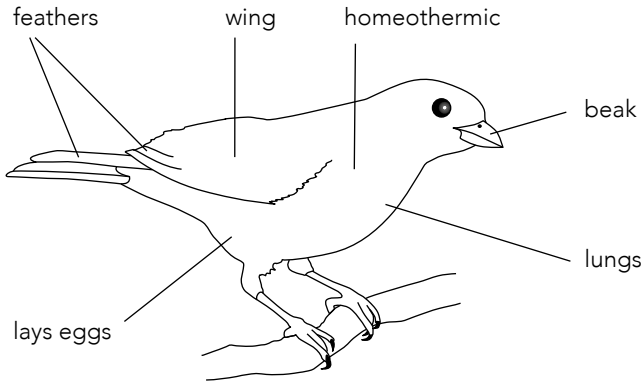

Figure 1.1: The parts of a bird.

a Identify the genus that birds belong to. ..... .

b List three observable characteristics that birds have.

.....

.....

.....

c State the word that describes birds being able to maintain their body temperature. ..... .

d Identify the type of fertilisation that birds use to reproduce. ..... .

e State the binomial name of the Brown falcon. .....

Exercise 1.4 Kingdom to species

When reading about different organisms and species, you need to remember the order of classification from kingdom to species.

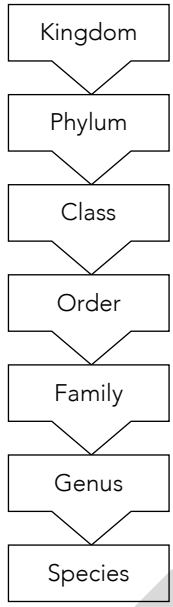

Figure 1.2: The order of classification from kingdom to species.

Using these terms in your writing is more difficult. This exercise will help you to use the different levels of organisation in your writing.

IN THIS EXERCISE YOU WILL:

Science skills:

- list the order of classification for an organism

English skills:

- write sentences to explain how different organisms are grouped together.

5 a Complete the description of the organism using the words in the box.
The text follows the order of classification from kingdom to species.

binomial **characteristic** **class** **family**
garlic **genus** **kingdom** **spermatophyte**

Allim sativum is known as ....., and it is a member of the *plantae* .....

The seeds of garlic are displayed externally and this ..... places the garlic into the ..... phylum.

The garlic belongs to the *liliopsida* ..... and the *asparagales* order.

The next level in the classification of garlic is the *Alliaceae* .....

The ..... name of the garlic is *Allium sativum,* which means that the ..... must be the Allium and the species is the sativum.

THE PASSIVE VOICE

In scientific writing we often use the passive voice. We use it because we do not always know who is doing the action and because 'who' is not always important; we are only interested in the action itself. For example: *Someone describes garlic in the text above.*

Who describes the garlic? We don't know who, but it is not important. So, this sentence is better: *Garlic is described in the text above.*

To make an active ('normal') present sentence passive, we:

Move the object to the front of the sentence to make it important (here = *Garlic*).

Decide if the word at the front (*Garlic*) is singular or plural, and choose the correct part of *be*: *am*, *are* or *is*? (here = *is*).

Use the past participle of the main verb in the active sentence (here = *describes*). With regular verbs, we add *-ed* to the verb (here = *describe* > *described*). With irregular verbs, you need a verb table; the past participle is the third part (for example: draw, drew, **drawn**/ choose, chose, **chosen**).

Someone describes ***garlic*** *in the text above.*
Garlic *is described in the text above.*
1 2 3

We will practise forming the passive in Chapter XX.

b There are two examples of the present passive in the text about garlic. Find and circle them. There are also two examples in the text about the Brown falcon, in Exercise 1.3. Can you see them?

6 Now it is your turn to construct a description of an organism. Use the text about garlic to help you. Choose an organism that interests you, research the information you need in books or on the internet, then write your description on the lines provided.

Include the following information:

- The names of each group that your organism fits into. For example: The lion belongs to the family *Felidae*.
- At least three observable characteristics of your organism that explain why it belongs to its group. Examples may include the family, the order, the class, the genus, the species.

……. is ……. . It is a member of the

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

LANGUAGE TIP

Some verbs like *state*, *identify*, and *list* are useful to know, because they tell you what you have to do to answer a question. Find examples of other verbs in the exercises so far and write down what each verb means. This will help you to understand them as you see them throughout the book.

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Biology

for Cambridge IGCSE™

MATHS SKILLS WORKBOOK

Gemma Young

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How to use this book

Throughout this book, you will notice lots of different features that will help your learning. These are explained below.

OVERVIEW

This sets the scene for each chapter, and explains why the maths skills in that chapter are important for you to understand.

WORKED EXAMPLES

These show a maths concept in action, giving you a step-by-step guide to answering a question related to that concept.

LOOK OUT

The information in these boxes will help you complete the questions, and give you support in areas that you might find difficult.

Practice questions

Questions give you a chance to practise the skills in each Maths focus. You can find the answers to these questions in the Teacher's Resource.

EXAM-STYLE QUESTIONS

Questions at the end of each chapter provide more demanding exam-style questions. Answers to these questions can be found in the Teacher's Resource.

APPLYING MORE THAN ONE SKILL

At the end of this Workbook you will find a section of exam-style questions covering any of the topics covered in the chapters. This will give you a chance to think about how to apply your maths skills to different contexts.

Throughout the book, you will see important words in **bold** font. You can find definitions for these words in the Glossary at the back of the book.

Chapter 1

Representing values

WHY DO YOU NEED TO REPRESENT VALUES IN BIOLOGY?

- In biology, you will take measurements when you are collecting data from investigations.
- Numerical data (numbers) must be recorded along with a suitable unit. This gives the number a value, which helps other people to understand it.
- Often the values used are very small or very big: for example, a cell might have a **diameter** of 0.000 01 metres. Converting units or using standard notation helps people to understand and compare values.

Maths focus 1: Using units

A biologist measured the length and mass of the fish in Figure 1.1.

She wrote down the measurements as 64 cm and 10.9 kg.

Figure 1.1: A type of fish called a carp.

When taking measurements in biology, it is important to choose a suitable **unit**.

The measuring apparatus you use can help you decide what units to use. The biologist used a tape measure that measured length in centimetres and weighing scales that measured mass in kilograms.

It is also correct to say that the fish has a length of 0.000 64 km and a mass of 10 900 g, but the biologist did not use these units because the numbers are either very small or very large. This makes the measurements harder to understand.

What maths skills do you need to be able to use units?

1	Choosing the correct unit	• Consider what measuring apparatus is being used and what the apparatus is measuring. • Choose the most suitable unit.
2	Using unit **symbols**	• Decide what the unit is. • Write the correct symbol.
3	Using **derived units**	• Identify the units being used. • Decide what the calculation is. • Work out the derived unit.

Maths skill practice

How and when do you use units in practical biology?

When doing practical work in biology, you will use apparatus to make measurements and collect data. It is important that you record this data using an appropriate unit.

For example, if you measure the length of a leaf and record it as 5, it is not clear whether you mean 5 mm or 5 cm. As the difference in length is significant, your results will not be understood correctly.

It is vital that you use the correct measuring equipment. For example, you would use a ruler marked in millimetres to measure the length of a leaf. This will allow you to give a more accurate measurement than a metre ruler marked only in centimetres.

Maths skill 1: Choosing the correct unit

Table 1.1 shows some of the common measurements used in biology, along with the apparatus that scientists use to take the measurements and the units that you use for these measurements.

Measurement	Apparatus	Unit
length/width	ruler, tape measure	millimetres, centimetres, metres
mass	weighing scales	grams, kilograms
volume	measuring cylinder, pipette	cubic centimetres
temperature	thermometer	degrees Celsius
time	stop clock	seconds

Table 1.1: Common measurements and apparatus used in biology.

LOOK OUT

Remember, mass is measured in kilograms (or grams). Weight is a force measured in newtons.

WORKED EXAMPLE 1.1

A student investigates transpiration using a potometer. Figure 1.2 shows the apparatus she uses.

See *Experimental skill 8.2 in the Coursebook* for more information on how to use a potomoter.

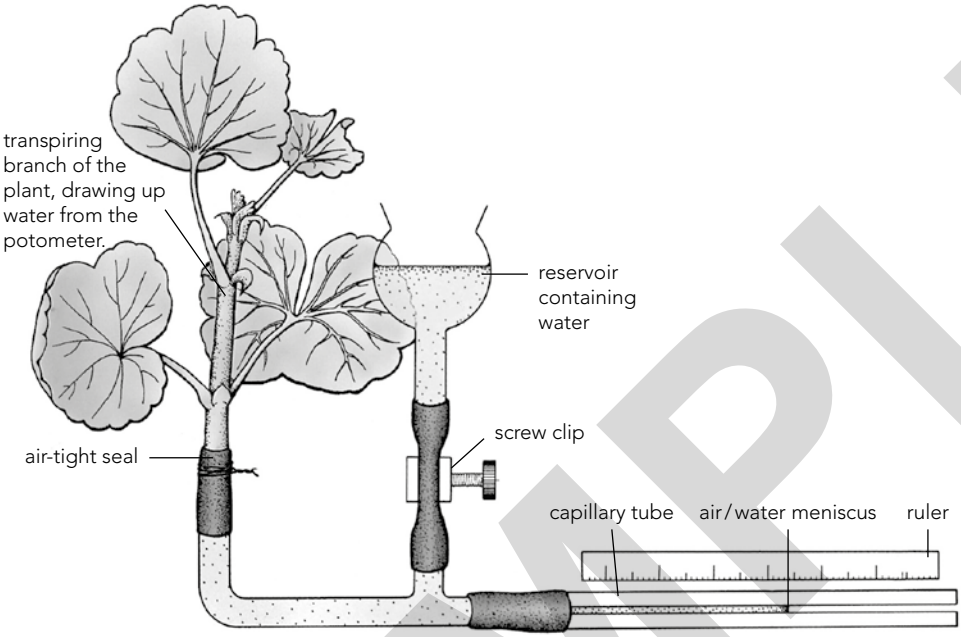


Figure 1.2: A potometer.

The student uses a ruler to measure the distance that the **meniscus** moves in 5 min. The ruler has divisions in both centimetres and millimetres.

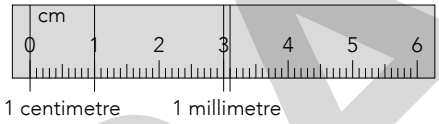


Figure 1.3: A ruler divided into millimetres and centimetres.

Which unit should the student use to measure the distance?

Key questions to consider:

- What measuring apparatus is being used?
- What is the apparatus measuring?
- What are the units of the divisions on the apparatus?
- Which unit is the most appropriate to use?

CONTINUED

The student should use millimetres. She could also use centimetres, although this would mean her data contain a decimal point.

It would be a mistake to use metres as the unit because the values would be too small. The student should choose a unit that will produce numbers that are not too small and not too large.

Questions

1 A biologist is investigating variation in physical characteristics in humans.
He asks a person to step onto some scales.

a What measurement is the biologist taking?

……..

b What would be the most appropriate unit to use?

……..

2 A student investigates how the height of a seedling changes over time. She decides to measure the height of the seedling in kilometres.

a Why would kilometres not be a good choice of unit to measure the height of the seedling?

……..

b Suggest a suitable unit.

……..

Maths skill 2: Using unit symbols

Instead of writing out the unit name each time, you can use a shorter version called a symbol (see Table 1.2).

Make sure you use the correct case for the letters in the symbols. For example, cm for centimetres is written in lower-case letters, but °C for degrees Celsius is an upper-case letter. Other units, for example kJ (kilojoules), contain both lower-case and upper-case letters.

Unit	Symbol	Unit	Symbol
metre	m	gram	g
centimetre	cm	degrees Celsius	°C
millimetre	mm	cubic centimetre	cm^3
kilogram	kg	second	s

Table 1.2: Some units and their symbols.

There are many more units used in biology than the ones in the table. These are formed by using derived units (see Maths skill 3 below) or unit prefixes.

WORKED EXAMPLE 1.2

A student did an osmosis experiment. The student cut up a potato into small cubes with sides of equal length. The student then placed the cubes into test-tubes, each containing the same amount of pure water.

You can read more about this experiment in *Chapter 3 of the Coursebook and Workbook*.

What measurements did the student take when he was setting up the experiment? What units should the student use for each measurement?

Length of sides of potato cube: the student should use millimetres.

Volume of salt solution: the student should use cubic centimetres.

Questions

3 Using Table 1.2, write down the unit symbol that you would use for each of the following measurements:

a volume of water measured using a pipette

……..

b thickness of a leaf

……..

c temperature of the room

……..

d time taken for an enzyme to break down a substrate

……..

4 Compare your answers to Practice question **3** with a partner.

Do you and your partner agree with all the symbols you chose in questions 3a–d? Remember, for many measurements there are different units that can be used.

If you don't agree with your partner, discuss why you choose a different unit.

Maths skill 3: Using derived units

Some units are made up (derived) from other units.

Concentration of a solution can be measured in grams per cubic centimetre, or g/cm^3. This unit came from a calculation. To calculate concentration you divide mass by volume:

$$\text{concentration} = \frac{\text{mass}}{\text{volume}}$$

So, the units are g/cm^3. This is a derived unit.

WORKED EXAMPLE 1.3

A scientist used a microscope to study pollen tubes growing (Figure 1.4).

Figure 1.4: A pollen tube.

A pollen tube grew 2.4 mm in 600 s.

What unit should the scientist use to show the rate of growth?

mm/s

(So, the rate of growth was $\frac{2.4}{600} = 0.004$ mm/s.)

LOOK OUT

Note that g/cm^3 can also be written as g cm^{-3}. Both of these units have the same meaning.

Questions

5 Write down the derived unit for each measurement being described.

a A quantity of sugar measured in grams was dissolved in a volume of water measured in cubic centimetres (cm^3).

……..

b A cat ran across a room. The time taken was measured in seconds.

……..

6 A student investigates an enzyme-catalysed reaction.

The student adds an enzyme to a substrate and then measures the volume of product made over a period of time.

Identify the derived unit that the student would use to present her data.

……

Maths focus 2: Representing very large and very small numbers

In biology you often have to use very small or large numbers.

For example:

- The diameter of a strand of DNA is 0.000 000 004 metres.
- There are around 37 200 000 000 000 cells in the human body.

Values written like this are hard to understand. It is easy to make a mistake and include incorrect numbers or miss some numbers out.

Also, writing them takes a long time, and a lot of space.

For these reasons biologists often use **standard form**.

Converting the values into standard form gives us:

- The diameter of a strand of DNA is 4×10^{-9} metres.
- There are around 3.72×10^{13} cells in the human body.

These numbers are shorter and clearer. It also helps you to compare the size of the numbers.

For example, 2.6×10^5 is around 100 times bigger than 2.2×10^3.

What maths skills do you need to represent very small and very large numbers?

1	Writing very large numbers in standard form	• Write the number as a number between 1 and 10, e.g. 900 is written as 9. • Count how many times the number has to be multiplied by 10, e.g. $900 = 9 \times 10 \times 10$ so it has to be multiplied by 10 twice. • Then convert the multiple of 10 to a **power of ten**, e.g. $9 \times 10 \times 10 = 9 \times 10^2$.
2	Writing very small numbers in standard form	• Write the number as a number between 1 and 9, e.g. 0.05 is written as 5. • Count how many times the number has to be divided by 10, e.g. $0.05 = 5 \div 10 \div 10$ so it has to be divided by 10 twice. • Then convert the multiple of 10 to a negative power of ten, e.g. $5 \div 10 \div 10 = 5 \times 10^{-2}$.

Maths skill 1: Writing very large numbers in standard form

WORKED EXAMPLE 1.4

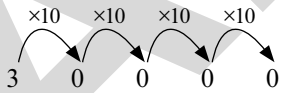
Convert the number 30 000 into standard form.

Step 1: Write the number as a number between 1 and 10.

For this number it is 3.

Step 2: Count how many times the number has to be multiplied by 10 to get the original number.

To convert the number 3 to 30 000 it has to be multiplied by 10 four times.



Step 3: Convert the multiple of 10 to a power of ten.

3×10^4 ← The 4 shows that we had to multiply 3 by 10 four times.

The number is now in standard form.

Questions

7 Convert these numbers to standard form.

a 50 000

……..

b 6700

……..

c 275 000 000

……..

8 Convert these numbers from standard form:

a 2.08×10^2

……..

b 9.25×10^5

……..

c 1.006×10^8

……..

9 A colony of bacteria contains 17 000 000 bacteria.
Write this number in standard form.

……

Check your answers before you continue to the next maths skill.

Maths skill 2: Writing very small numbers in standard form

WORKED EXAMPLE 1.5

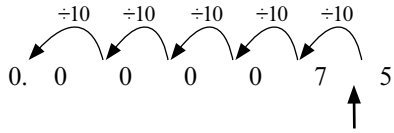
Convert the number 0.000 075 into standard form.

Step 1: Write the number as a number between 1 and 10.

For this number it is 7.5.

Step 2: Count how many times the number has to be divided by 10.

To convert the number 7.5 to 0.000 075, it has to be divided by 10 five times.



The decimal point was here

Step 3: Convert the multiple of 10 to a negative power of ten.

7.5×10^{-5} ← The −5 shows that we had to divide 7.5 by 10 five times

The number is now in standard form.

LOOK OUT

In standard form the decimal point is always placed after the first non-zero figure.

Questions

10 Convert these numbers to standard form.

a 0.003

……

b 0.000 060 8

……

c 0.000 000 041 08

……

11 Convert these numbers from standard form:

a 6×10^{-4}

……

b 7.22×10^{-7}

……

c 5.008×10^{-3}

……

12 The diameter of an animal cell is 0.000 105 metres.
Write this in standard form.

.....

13 Which do you find easiest: converting large numbers or small numbers to standard form? Why do you find this type of conversion easier?
Write some more questions for yourself and ask a partner to check your answers.

.....

.....

.....

Maths focus 3: Using unit prefixes and converting units

When you measure mass at school you will normally use the unit grams.

However, grams are not an appropriate unit to measure the mass of much smaller or larger objects. Here are the masses of two animals, a giant tortoise (Figure 1.5) and a mosquito (Figure 1.6):

Mass of a giant tortoise = 200 000 g

Mass of a mosquito = 0.0025 g

Figure 1.5: A giant tortoise.

Figure 1.6: A mosquito.

You can add a **unit prefix** to the start of a unit to change its value.

For example, the prefix kilo- makes the unit 1000 times larger. So:

1 kg = 1000 g

The prefix milli- makes the unit 1000 times smaller. So:

1 mg = 0.001 g

You can use these to convert the masses of the animals to a more appropriate unit:

Mass of a giant tortoise = 200 kg

Mass of a mosquito = 2.5 mg

What maths skills do you need to use unit prefixes and convert units?

1	Using powers of ten	• Write powers of tens as numbers. • Write numbers as powers of ten.
2	Using negative powers of ten	• Write negative powers of tens as numbers. • Write numbers as negative powers of ten.
3	Using unit prefixes	• Convert the number into a power of ten.
4	Converting units	• Decide if you need to multiply or divide. • Do the calculation. Remember to add units to your answer. • Check that the size of the answer looks correct.

Maths skill 1: Using powers of ten

You already know that 10^2 can be read as '10 squared' and means 10×10. Its value is 100.

It can also be read as '10 to the power of 2'.

The small number is the **power** or **index**. It shows how many times we multiply by 10; see Table 1.3.

The number of zeros in the value is the same as the power. So 10^2 is 100, which shows that 1 has been multiplied by 10 two times.

Power of ten	Multiplying tens	Value	Name
10^0	–	1	one
10^1	10	10	ten
10^2	10×10	100	one hundred
10^3	$10 \times 10 \times 10$	1000	one thousand
10^4	$10 \times 10 \times 10 \times 10$	10000	ten thousand
10^5			
10^6			

Table 1.3: Some powers of ten and their values.

LOOK OUT

Leaving a space between every three digits makes larger numbers easier to read. For example, one million written as 1 000 000 is easier to recognise than 1000000.

WORKED EXAMPLE 1.6

Explain why 1000 can also be written as 10^3.

$1000 = 10 \times 10 \times 10$

So, 10 is multiplied by itself 3 times.

This can be written as 10^3.

Questions

14 Complete the final two rows of Table 1.3.

15 Write the following as powers of ten:

a 1000

……

b 1 000 000 000

……

c 10 million

……

16 Write the values of the following powers of ten:

a 10^5

……

b 10^8

……

c 10^{10}

……

Maths skill 2: Using negative powers of ten

Powers of ten can also have negative values.

Table 1.4 shows how these are calculated.

Power of ten	Dividing tens	Value	Name
10^{-1}	$1 \div 10$	0.1	one tenth
10^{-2}	$1 \div (10 \times 10)$	0.01	one hundredth
10^{-5}	$1 \div (10 \times 10 \times 10 \times 10 \times 10)$	0.00001	one hundred thousandth
10^{-6}	$1 \div (10 \times 10 \times 10 \times 10 \times 10 \times 10)$	0.000001	one millionth

Table 1.4: Calculating negative powers of ten.

The negative index or power of ten tells you how many times to divide by 10:

$$10^{-2} \text{ is } \frac{1}{10 \times 10} = \frac{1}{100}$$

$$10^{-5} \text{ is } \frac{1}{10 \times 10 \times 10 \times 10 \times 10} = \frac{1}{100\,000}$$

WORKED EXAMPLE 1.7

Explain why 0.01 can also be written as 10^{-2}.

$0.01 = 10 \div 10 \div 10$

So, 10 is divided by itself twice.

This can be written as 10^{-2}.

Questions

17 Complete the missing two rows of Table 1.4.

18 Write the following values as powers of ten:

a 0.01

……..

b 0.000 000 000 1

……..

c one ten millionth

……..

19 Write the values of the following powers of ten:

a 10^{-1}

……..

b 10^{-4}

……..

c 10^{-8}

……..

Maths skill 3: Using unit prefixes

A prefix is added to the start of a unit to change its value.

Each prefix has a power of ten associated with it.

Table 1.5 shows the most common prefixes used in biology.

Prefix	Prefix symbol	Power of ten	Example	
			Unit name	Unit symbol
kilo-	k	10^3	kilometre	km
–	–	10^0	metre	m
deci-	d	10^{-1}	decimetre	dm
centi-	c	10^{-2}	centimetre	cm
milli-	m	10^{-3}	millimetre	mm
micro-	μ	10^{-6}	micrometre	μm
nano-	n	10^{-9}	nanometre	nm

Table 1.5: Common prefixes used in biology.

LOOK OUT

The symbol for the prefix micro- might look like a letter 'u' in some print, but it is in fact a Greek letter (called mu), μ. Make sure you write it correctly.

WORKED EXAMPLE 1.8

The length of a bacterial cell is 0.000 001 m.

It is better to display this value by using either standard form or a unit with a prefix.

$0.000\,001 = 1 \times 10^{-6}$

so

$0.000\,001 \text{ metres} = 1 \times 10^{-6} \text{ metres} = 1\,\mu\text{m}$

Questions

20 Write the missing unit symbol.

The first has been done as an example.

a 10^3 metres = 1 km

b 10^3 g = 1 .....

c 10^{-2} m^3 = 1 .....

d 10^{-3} s = 1 .....

e 10^{-9} J = 1 .....

21 A cell membrane is 0.000 000 01 metres thick.

Write this number down using a more appropriate unit.

.....

.....

.....

Maths skill 4: Converting units

When you want to compare two objects, it is helpful to convert data so that the measurements are in the same units for both objects.

For example, two objects have the masses 0.45 g and 900 mg. Converting both of the measurements to milligrams will give you the values 450 mg and 900 mg, so you can see that the second mass is double the first.

Table 1.6 shows you how to convert units.

	Prefix	Example	Power of ten	
	kilo-	kg	10^3	× 1000
÷ 1000	–	g	10^0	× 1000
÷ 1000	milli-	mg	10^{-3}	× 1000
÷ 1000	micro-	µg	10^{-6}	× 1000
÷ 1000	nano-	ng	10^{-9}	

Table 1.6: Converting units.

LOOK OUT

Check your answer by looking at its size. For example, you know that microgram (µg) is a smaller unit than gram (g), so it makes sense that 10 µg would be a small number when converted into grams.

WORKED EXAMPLE 1.9

Convert 10 µg into grams.

To convert micrograms to grams, you need to divide the number by 1000 twice (1000^2).

$$\frac{10}{1000^2} = 0.000\,01\text{ g}$$

Questions

22 Convert the following numbers:

a 1 metres into millimetres

……..

b 14 g into kilograms

……..

c 1200 µm into millimetres

……..

23 The diameter of a red blood cell is 8 µm. Convert this into millimetres.

……

EXAM-STYLE QUESTIONS

1 a A student investigated how caffeine found in an energy drink affected her reaction time. The student decided to use an energy drink that contains 80 mg of caffeine in a 250 cm^3 can.

Calculate the amount of caffeine in the drink in mg/cm^3.

……

…… **[1]**

b The student measured her reaction time five times before drinking the energy drink.

To get accurate results the student used a computer program to do this.

Her results were:

0.315 s 0.423 s 0.345 s 0.478 s 0.278 s

i Calculate her mean reaction time in seconds.

……

…… **[1]**

COMMAND WORD

calculate: work out from given facts, figures or information

CONTINUED

ii Convert this time to milliseconds.

.....

..... [1]

c Next, the student needed to drink a cup of the energy drink.

Suggest a suitable unit for measuring the volume of energy drink.

Explain why you chose this unit.

.....

..... [2]

d Next, the student waited 10 min and then she repeated the reaction time test.

The student's new mean reaction time was lower than her mean reaction time before she drank the energy drink. What conclusion can the student make from this evidence?

..... [1]

[Total: 6]

COMMAND WORD

explain: set out purposes or reasons / make the relationships between things evident / provide why and/or how and support with relevant evidence

2 A scientist counted 9856 white blood cells in 1 µl of blood.

a Calculate an estimate for the number of white blood cells in 5 litres of blood (the average volume of blood in an adult man).

.....

.....

..... [3]

b Write the answer in standard form.

..... [1]

[Total: 4]