1 Classification

In this chapter, you will find out about:

- the characteristics of living things
- naming organisms using the binomial system
- how living organisms are classified
- how to use dichotomous keys to identify organisms.

The puzzle of the platypus

In 1788, British settlers arrived in Australia. They were amazed by many of the animals that they saw, and a strange animal with fur, webbed feet and a beak was among the most puzzling (Figure **1.1**).

People had already been living in Australia for almost 50 000 years, and different groups of these indigenous people had various names for this animal, such as dulawarrung. But the British arrivals were not satisfied with just giving the animal a name. They wanted to classify it – to decide which group of animals it belonged in.

And this was where the problem began. 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.

In 1799, a dead specimen of this strange animal was taken to England, where it was studied by Dr George Shaw. To begin with, he thought it was a hoax. He looked very carefully to see if someone had stitched the beak onto the head, but no – it 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 by a German scientist, who gave it the name *Ornithorhynchus paradoxus*. The first word means 'nose like a bird' and the second means 'puzzling'. This is the Latin name that is used for the animal today.

Although the Latin name *Platypus* could not be used, people still called the animal a platypus. In the following years, 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, despite its odd beak and the fact that it lays eggs. It was put into a new group of mammals, called monotremes, which also includes the echidnas (spiny anteaters).

Figure 1.1 The platypus is superbly adapted for hunting prey in water.

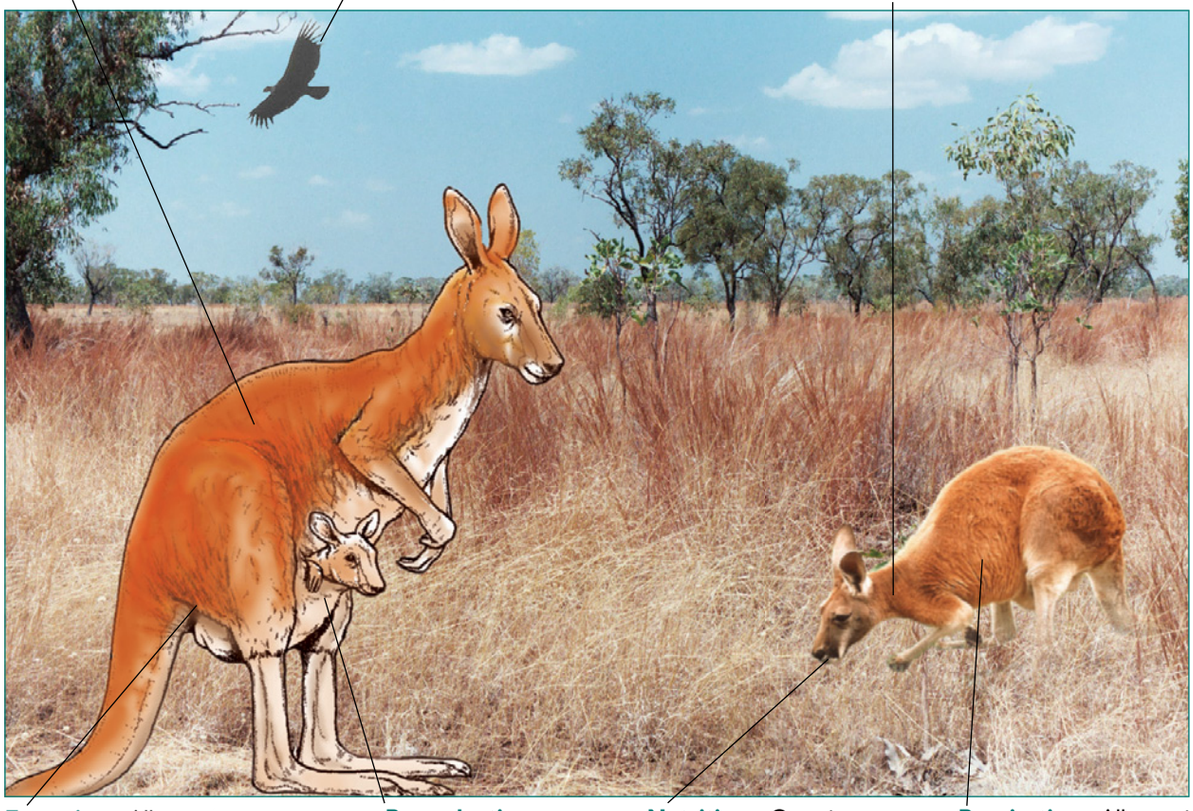
1.1 Characteristics of living things

Biology is the study of living things, which are often called **organisms**. Living organisms have seven features or characteristics which make them different from objects that are not alive (Figure **1.2**). The definitions of these characteristics are shown in the boxes below and on the opposite page. You should learn these definitions now, but you will find out much more about each of them later in this book.

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.

Key definitions

movement – an action by an organism causing a change of position or place
respiration – the chemical reactions in cells that break down nutrient molecules and release energy
sensitivity – the ability to detect and respond to changes in the environment
growth – a permanent increase in size
reproduction – the processes that make more of the same kind of organism
excretion – removal from organisms of toxic materials and substances in excess of requirements
nutrition – taking in of materials for energy, growth and development

Key definitions

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

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

sensitivity – the ability to detect or sense stimuli in the internal or external environment and to make appropriate responses

growth – a permanent increase in size and dry mass by an increase in cell number or cell size or both

excretion – removal from organisms of the waste products of metabolism (chemical reactions in cells including respiration), toxic materials and substances in excess of requirements

nutrition – taking in of materials for energy, growth and development; plants require light, carbon dioxide, water and ions; animals need organic compounds and ions and usually need water

In addition to these seven characteristics, living organisms have another feature in common. When we study living organisms under a microscope, we can see that they are all made of cells. These cells all have:

- cytoplasm
- a cell membrane
- a chemical called DNA, making up their genetic material
- ribosomes, which are used for making proteins inside the cell
- enzymes that are used to help the cell to carry out anaerobic respiration.

You can find out more about the structure of cells in Chapter **2**.

1.2 Classification

Classification means putting things into groups. There are many possible ways in which we could group living organisms. For example, we could put all the organisms with legs into one group, and all those without legs into another. Or we could put all red organisms into one group, and all blue ones into another. The first of these ideas would be much more useful to biologists than the second.

The main reason for classifying living things is to make it easier to study them. For example, we put humans, dogs, horses and mice into one group (the mammals) because they share certain features (for example, having hair) that are not found in other groups. We think that all mammals share these features because they have all descended from the same ancestor that lived long ago. The ancestor that they all share is called a **common ancestor**. The common ancestor that gave rise to all the mammals lived more than 200 million years ago.

We would therefore expect all mammals to have bodies that have similar structures and that work in similar ways. If we find a new animal that has hair and suckles its young on milk, then we know that it belongs in the mammal group. We will already know a lot about it, even before we have studied it at all.

Using DNA to help with classification

In the past, the only ways that biologists could decide which organisms were most closely related to each other was to study the structure of their bodies. They looked carefully at their **morphology** (the overall form and shape of their bodies, such as whether they had legs or wings) and their **anatomy** (the detailed body structure, which could be determined by dissection). We still use these methods of classification today. But we now have new tools to help to work out evolutionary relationships, and one of the most powerful of these is the study of **DNA**.

DNA is the chemical from which our chromosomes are made. It is the genetic material, passed on from one generation to the next. You can read more about its structure in Chapter **4**, where you will find out that each DNA molecule is made up of strings of smaller molecules, containing four different **bases**. These bases, called A, C, G and T, can be arranged in any order. Biologists can compare the sequences of bases

S in the DNA of organisms from two different species. The more similar the base sequences, the more closely related the species are to one another. They have a more recent common ancestor than species that have DNA base sequences that are less similar. The similarities in sequences of amino acids in proteins can be used in the same way.

The classification system

The first person to try to classify organisms in a scientific way was a Swedish naturalist called Linnaeus. He introduced his system of classification in 1735. He divided all the different kinds of living things into groups called **species**. He recognised 12 000 different species. Linnaeus's species were groups of organisms that shared the same appearance and behaviour. We still use this system today. Biologists do not always agree on exactly how to define a species, but usually we say that organisms belong to the same species if they can breed together successfully, and the offspring that they produce can also breed.

Species are grouped into larger groups called genera (singular: **genus**). Each genus contains several species with similar characteristics (Figure **1.3**). Several genera are then grouped into a family, families into orders, orders into classes, classes into phyla and finally phyla into **kingdoms**. Some of the more important groups are described in this chapter.

Figure **1.3** shows five animals that all belong to the mammal order. You can see that they all have hair, which is a characteristic feature of mammals. The animals have been classified into two groups – horse-like mammals and dog-like mammals. (What features do you think differ between these two groups?) The horse-like mammals all belong to the genus *Equus*. The dog-like ones belong to the genus *Canis*.

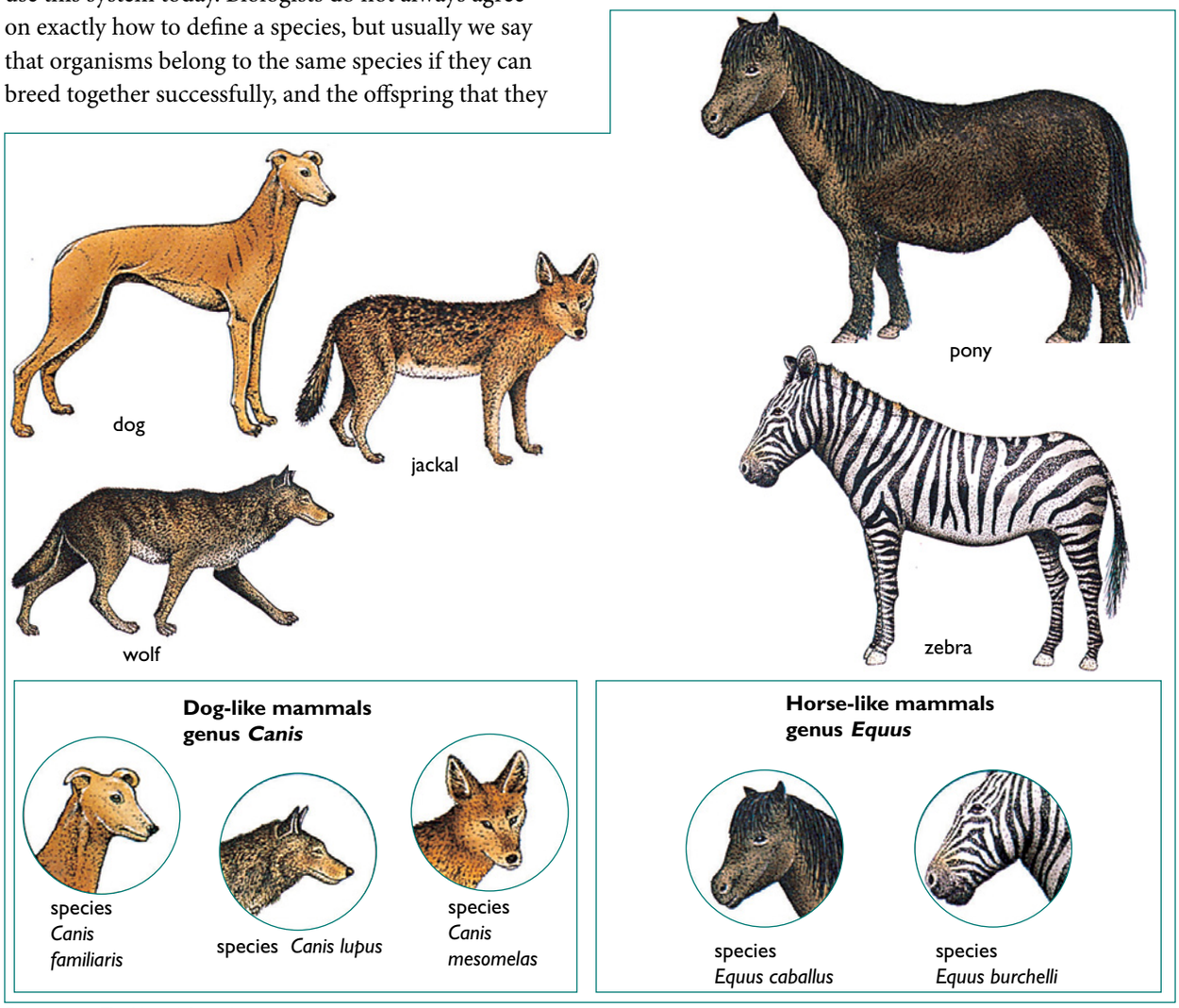


Figure 1.3 The binomial naming system.

The binomial naming system

Linnaeus gave every species of living organism two names, written in Latin. This is called the **binomial system**. The first name is the name of the genus the organism belongs to, and always has a capital letter. The second name is the name of its species, and always has a small letter. This two-word name is called a **binomial**.

For example, a wolf belongs to the genus *Canis* and the species *lupus*. Its binomial is *Canis lupus*. These names are printed in italics. When you write a Latin name, you cannot write in italics, so you should underline it instead. The genus name can be abbreviated like this: *C. lupus*.

Key definition

species – a group of organisms that can reproduce and produce fertile offspring
binomial system – an internationally ageeed system in which the scientific name of an organism is made up of two parts showing the genus and species

Study tip

Do take care to write Latin names (binomials) correctly. You will often see them written wrongly in the media! You should always use a capital letter for the first name and a small letter for the second name.

Question

1.1 The table shows how two organisms – a monarch butterfly and a giant pangolin – are classified.

a Use the informatiton in the table to suggest whether these two organisms are not related at all, distantly related or closely related. Explain how you made your decision.

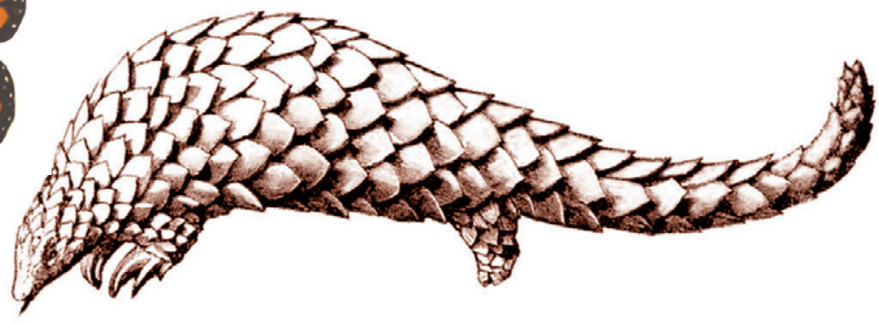
b Write down the genus of the giant pangolin.

c Use the Internet or a textbook to find out how a human is classified. Write it down in a table like the one shown on the right.

Kingdom	animal	animal
Phylum	arthropods	vertebrates
Class	insects	mammals
Order	Lepidoptera (butterflies and moths)	Pholidota
Family	Danaidae	Manidae
Genus	*Danaus*	*Manis*
Species	*Danaus plexippus*	*Manis gigantea*

Monarch butterfly

Giant pangolin



1.3 The kingdoms of living organisms

Animals

Animals (Figure **1.4**) are usually easy to recognise. Most animals can move actively, hunting for food. Under the microscope, we can see that their cells have no cell walls.

Some animals have, in the past, been confused with plants. For a very long time, sea anemones were classified as plants, because they tend to stay fixed in one place, and their tentacles look rather like flower petals. Now we know that they are animals.

Characteristics:

- multicellular (their bodies contain many cells)
- cells have a nucleus, but no cell walls or chloroplasts
- feed on organic substances made by other living organisms.

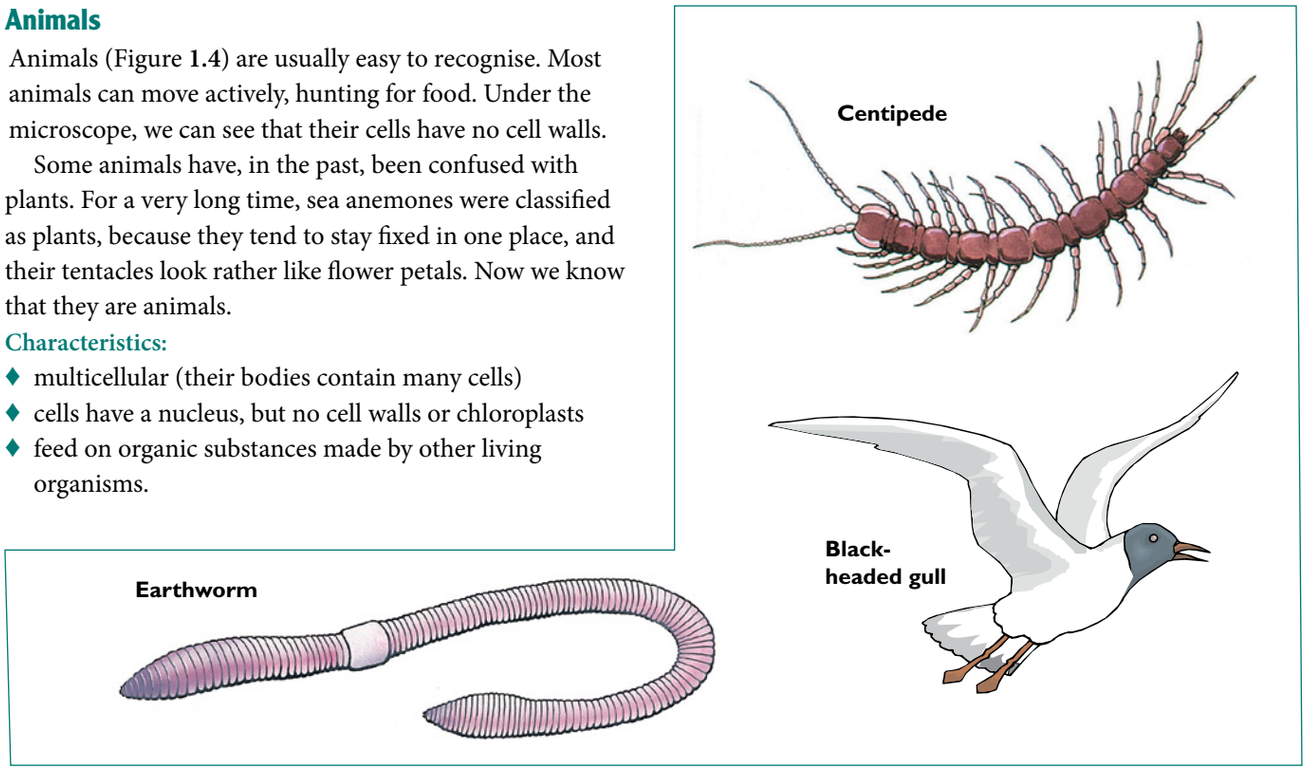


Figure 1.4 Some examples of animals.

Plants

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 (Figure **1.5**). 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.

As 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.

Characteristics:

- multicellular
- cells have a nucleus, cell walls made of cellulose and often contain chloroplasts
- feed by photosynthesis
- may have roots, stems and leaves.

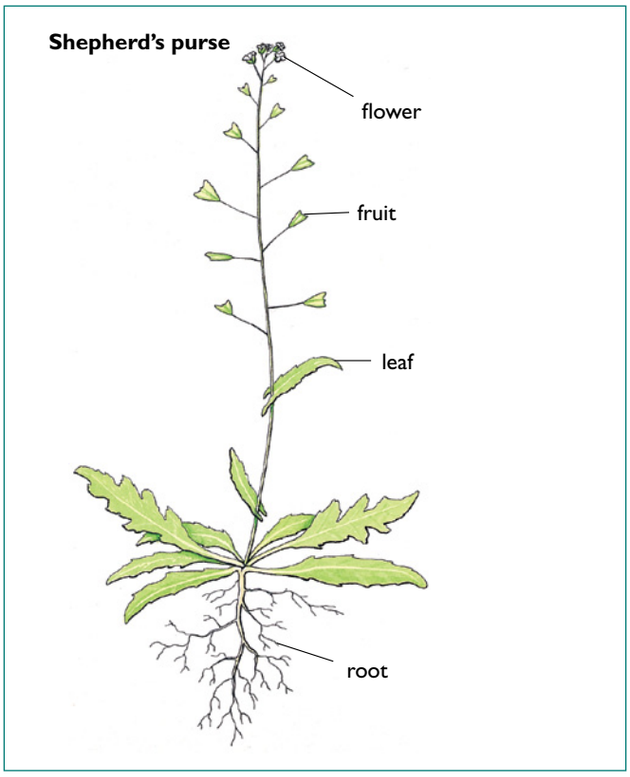


Figure 1.5. An example of a plant.

Questions

1.2 The photograph below shows a sea anemone.

a Explain why people used to think that sea anemones were plants.

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

1.3 The photograph below shows a plant called a liverwort. Liverworts do not have roots or proper leaves. They do not have flowers. Suggest how you could show that a liverwort belongs to the plant kingdom.

Fungi

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 **1.6** shows the characteristic features of fungi.

We have found many different uses to make of fungi. We eat them as mushrooms. We use the unusual fungus yeast to make ethanol and bread. 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.

Fungi do not have chlorophyll and do not photosynthesise. Instead they feed saprophytically, or parasitically, on organic material like faeces, human foods and dead plants or animals.

Characteristics:

- usually multicellular (many-celled)
- have nuclei
- have cell walls, not made of cellulose
- do not have chlorophyll
- feed by saprophytic or parasitic nutrition.

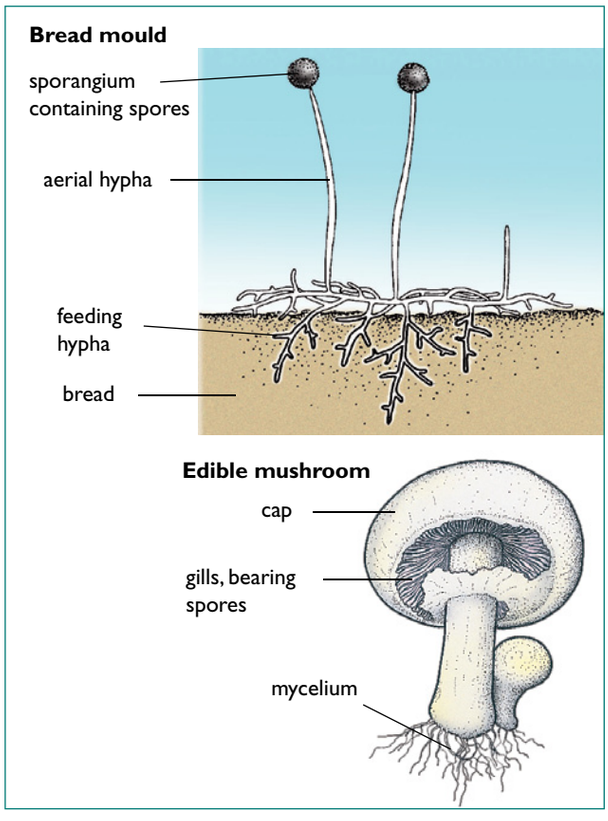


Figure 1.6 Some examples of fungi.

Protoctista

The kingdom Protoctista (Figure 1.7) contains quite a mixture 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.

Characteristics:

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

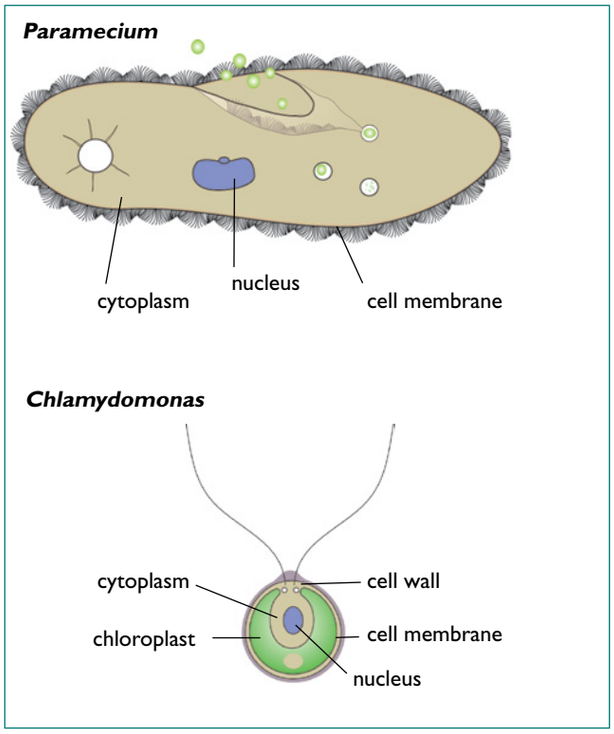


Figure 1.7 Some examples of protoctists.

Prokaryotes

Figure 1.8 shows some bacteria. Bacteria have cells that are very different from the cells of all other kinds of organism. The most important difference is that they do not have a nucleus.

You will meet bacteria at various stages in your biology course. Some of them are harmful to us and cause diseases such as tuberculosis (TB) and cholera. Many more, however, are helpful. You will find out about their useful roles in the carbon cycle and the nitrogen cycle, in biotechnology, in the treatment of sewage to make it safe to release into the environment and in making insulin for the treatment of people with diabetes.

Some bacteria can carry out photosynthesis. The oldest fossils belong to this kingdom, so we think that they were the first kinds of organism to evolve.

Characteristics:

- often unicellular (single-celled)
- have no nucleus
- have cell walls, not made of cellulose
- have no mitochondria.

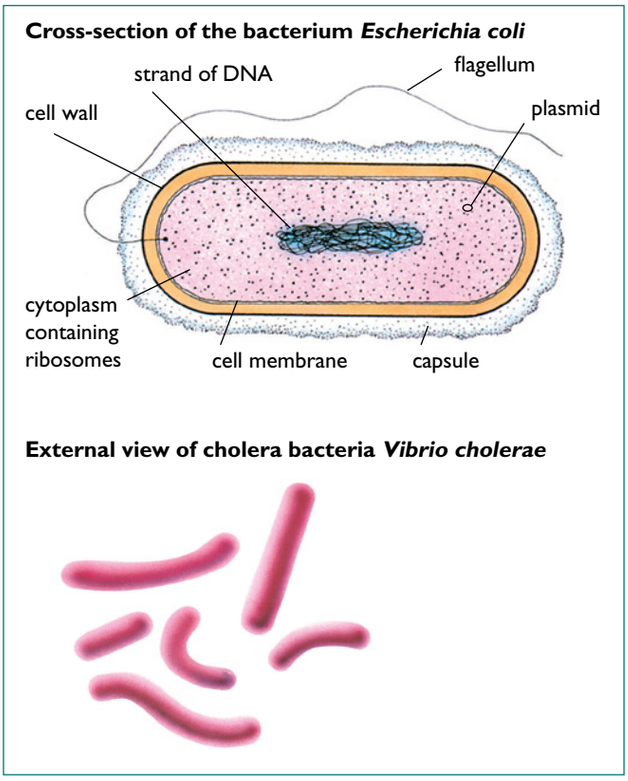


Figure 1.8 Some examples of bacteria.

S 1.4 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 alive, 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.

Figure **1.9** shows one kind of virus. It is not made of a cell – it is simply a piece of DNA or RNA (a chemical similar to DNA) 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} mm. In other words, you could line up more than 15 000 of these viruses between two of the millimetre marks on your ruler.

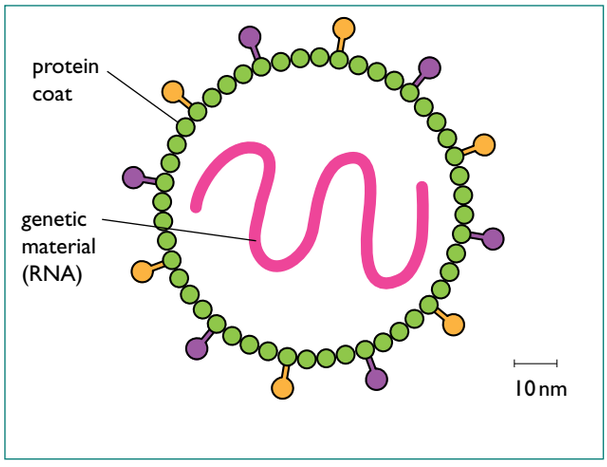


Figure 1.9 The structure of a simple virus

Questions

S **1.4** Why are viruses not generally considered to be living things?

1.5 State **one** similarity and **one** difference between the cells of a fungus and the cells of a plant.

1.6 How do the cells of bacteria differ from the cells of plants and animals?

1.5 Classifying animals

Figure **1.10** shows some of the major groups into which the animal kingdom is classified.

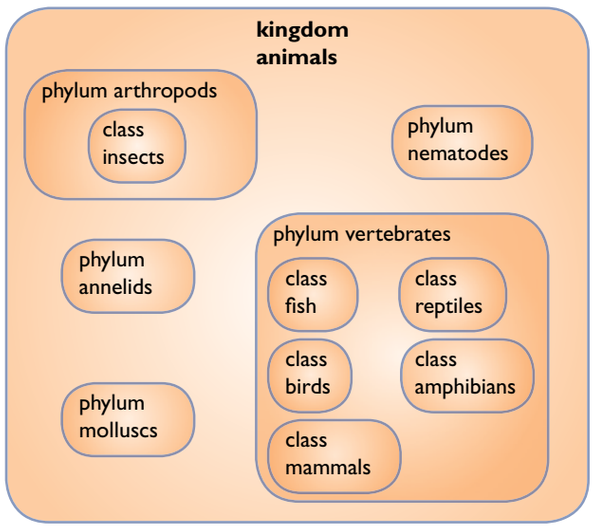


Figure 1.10 Classification of the animal kingdom.

Phylum Vertebrates

These are animals with a supporting rod running along the length of the body. The most familiar ones have a backbone and are called vertebrates.

Class Fish

The fish (Figure **1.11**) all live in water, except for one or two like the mudskipper, which can spend short periods of time breathing air.

Characteristics:

- vertebrates with scaly skin
- have gills
- have fins.

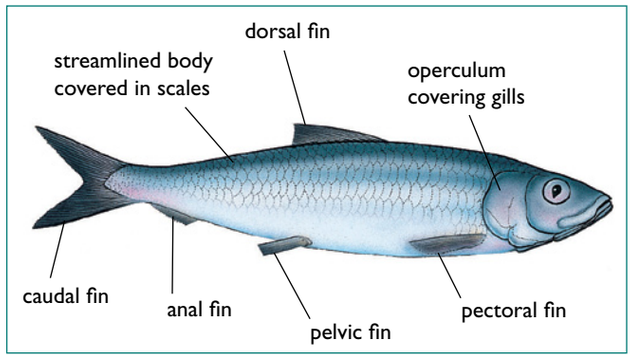


Figure 1.11 A fish.

Class Amphibians

Although most adult amphibians live on land, they always go back to the water to breed. Frogs, toads and salamanders are amphibians (Figure **1.12**).

Characteristics:

- vertebrates with moist, scale-less skin
- eggs laid in water, larva (tadpole) lives in water
- adult often lives on land
- larva has gills, adult has lungs.

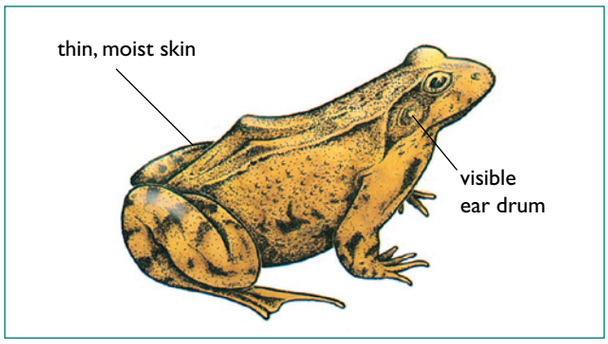


Figure 1.12 A frog.

Class Reptiles

These are the crocodiles, lizards, snakes, turtles and tortoises (Figure **1.13**). Reptiles do not need to go back to the water to breed because their eggs have a waterproof shell which stops them from drying out.

Characteristics:

- vertebrates with scaly skin
- lay eggs with rubbery shells.

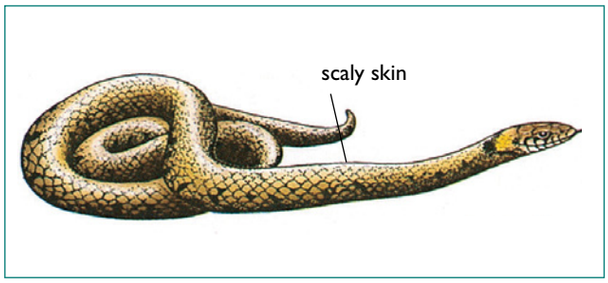


Figure 1.13 A snake.

Class Birds

The birds (Figure **1.14**), like reptiles, lay eggs with waterproof shells.

Characteristics:

- vertebrates with feathers
- forelimbs have become wings
- lay eggs with hard shells
- endothermic
- have a beak
- heart has four chambers.

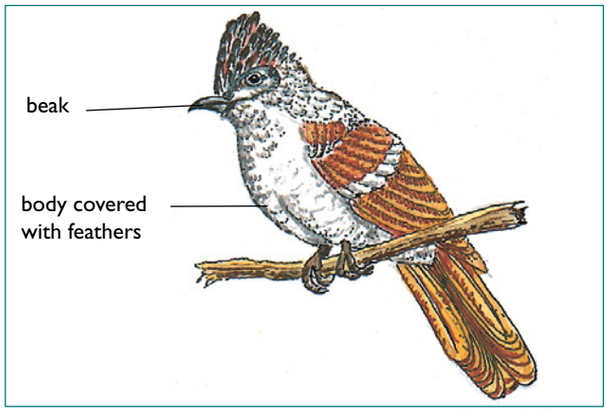


Figure 1.14 A bird.

Class Mammals

This is the group that humans belong to (Figure **1.15**).

Characteristics:

- vertebrates with hair
- have a placenta
- young feed on milk from mammary glands
- endothermic
- have a diaphragm
- heart has four chambers
- have different types of teeth (incisors, canines premolars and molars).

Figure 1.15 An ocelot, an example of a mammal.