Classification

Unit 5

Contents

5.1 Principles of classification

By the end of this section you should be able to:

- Explain the need for classification.
- Define species as a group of individuals able to breed successfully with one another.
- Describe the system of binomial nomenclature developed by Linnaeus.
- Explain how organisms are given scientific names.
- Write scientific names properly and give examples.
- Classify some common plants and animals, including humans, using their scientific names.

On Earth today there are many types of living things. This great variety of life is called diversity or biodiversity.

To help us understand the great diversity of living things we put them into groups. This grouping of similar living things is known as classification.

Biologists classify living things for the following reasons:

1. To simplify their study.
2. To bring order out of chaos or confusion.
3. To try to understand how life originated.

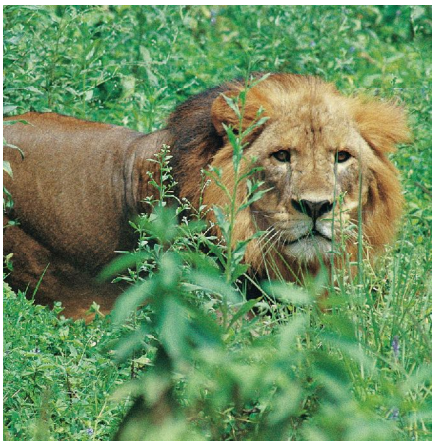

Figure 5.1 *In countries like Ethiopia alone, the number of living organisms is enormous. A system of classification is important to help us understand the different types of living things there are.*

What is a species?

Classifying living organisms is central to understanding the variety of life on Earth. Scientists group organisms together in different ways, as you will see shortly. But the most important unit of classification is the **species**. Species are defined in many different ways, but the most common and widely used definition of a species is: *A group of organisms that can breed successfully with one another to produce fertile offspring.* So, for example, horses and donkeys look similar, but the offspring produced from a horse and a donkey is a mule, which is sterile. So horses and donkeys are not the same species. But the offspring produced between a Borena and a British Friesian will be fertile – the different cattle breeds are variants of the same species.

In the 21st century scientists make decisions about which organisms belong in the same species in a number of ways.

How are living things classified?

Living things are classified according to how similar they are. We use similarities on or in their bodies to group them. One example is animals that are put in a group together because their limbs are built on the same basic plan. The limbs of a bat, horse, bird, human and whale all have the same basic pattern though they are used in different ways.

The front limbs of a bat are adapted as wings and used for flying and climbing, whereas the limbs of a horse are used for galloping. The front limbs of a bird are also used for flying, whereas human front limbs are for using tools. In a whale, the front limbs are used for swimming. Each of these animals looks very different – yet if we look at their skeletons the bones in their front limbs are all recognisably the same. These limbs are called homologous structures. They have the **pentadactyl** limb pattern or five-digit plan and this has been very useful both for classifying the organisms and for tracing back their ancestors through ancient history.

Many other features, from the numbers of hairs on the leg of an insect to the numbers of petals on the flower of a plant or the chemistry of the blood are also used for classification. These are known as the characteristics of the organism. Classification began centuries ago with the careful observations of scientists and anyone interested in natural history. Now, in the 21st century, we use technology to allow us to look at the genetic make-up of living organisms so that we can be sure that they are related to each other – or not!

KEY WORDS

species *a group of organisms that can breed successfully with one another to produce fertile offspring*

pentadactyl *having five fingers or toes*

Originally scientists just looked closely at the outer (and sometimes inner) appearance or **morphology** of the organism. Classification was based on the degree of difference or similarity in the way they looked. Different features – for example, the number of hairs on the leg of an insect, the arrangement of fins and scales on a fish – were used to group them into species, genus and so on. In many cases you can tell just by looking at an organism what it is – you would never mistake a lion for a cheetah, for example. However, the appearance of an organism can be affected by many different things, and there can be a huge amount of variation within a group of closely related organisms.

Today there are more sophisticated ways of comparing organisms. The fundamental chemicals of life – such as DNA, RNA and proteins – are found in almost all organisms. However, while these chemicals are broadly similar across all species, we can find differences when the molecules are broken down to their constituent parts. Sometimes scientists use these differences to decide which species an organism belongs to.

Figure 5.2 *British Friesian (top) and Borena cattle do not look very similar – but they are the same species and will produce fertile offspring.*

KEY WORDS

morphology *appearance of an organism*

taxonomy *process of classifying living organisms*

taxa *category in classification*

The classification system

The process of classifying living organisms is known as **taxonomy**, and the system we use groups living things into categories called **taxa**. The main taxonomic categories are kingdom, phylum (or for plants, division), class, order, family, genus and species.

The largest groups into which living organisms are divided are the kingdoms. Kingdoms are subdivided into phyla, each phylum into classes, each class into orders, each order into families, each family into genera and each genus into species. The species is the smallest unit of classification. There will be many different types of organisms in a phylum, all of which have a few characteristics in common. There will be far fewer organisms in a genus – but they will all have a lot of features in common. A species only contains one type of organism, which have all their main features in common!

Naming living things

The many varieties of living organisms means there are even more names! People in different areas of Africa speak many different languages. In Ethiopia alone we have 85 living languages – and at least 11 of those have over a million native speakers! And many of us speak more than one language, often including English! All of the different languages will have different names for the same animal or plant. For example, the Ethiopian wolf is also known as the Abyssinian wolf, Simien fox, Ethiopian jackal, red jackal and Simien jackal in English, as *Qey kebero* in Amharic and *jedala dima* in Afan Oromo and *Keyih Wukaria* in Tigrigna. It is also named differently in different other Ethiopian languages. Around the world you also have to add languages such as English, French, Russian and Chinese into the mixture. It becomes impossible for one scientist to know what organism another scientist is talking about!

The problem is solved because every organism that is classified is given a scientific name.

Taxonomy began with the work of Aristotle, a philosopher who lived in Ancient Greece from 384–322 BC. He tried to create a classification system for the living world, and grouped animals by similarities such as 'animals that live on land' and 'animals that live in water'. He thought that some animals were higher up the order of nature than others, with human beings at the very top. He even tried to give everything a scientific name with two parts to it – he called humans 'rational animals'. However, his system was never finished.

Taxonomy became a serious science with the work of Carl Linnaeus in the 18th century. Linnaeus loved to collect plants. He qualified as a doctor, but then went back to study plants. He developed the binomial system of nomenclature for organisms, which he published in a book called *The System of Nature*. He suggested a way of organising living organisms from the kingdoms downwards, with a binomial system of naming them that is still used today. **Binomial** means two names. The two names of an organism are in Latin. Even in the time of Linnaeus, Latin was no longer spoken anywhere in the world. However, it was the language of scholars everywhere. This meant no one was offended because their language was not chosen to identify animals and plants – yet most people could understand the names. So, for example, the wolf with so many names in Ethiopia is known to all scientists as *Canis simensis* – so no one gets confused.

KEY WORD

binomial *having two names*

Simple rules for writing scientific names

1. The first name is the name of the genus to which the organism belongs. It is written with a capital letter. Sometimes the name of the genus is reduced to just the capital letter, e.g. *H. sapiens*, *C. simensis*.
2. The second name is the name of a species to which the organism belongs. It is written with a small letter.
3. The two names are underlined when handwritten or in italics when printed.

Table 5.1 *Examples of scientific names of some common organisms*

Common name	Scientific name
Human beings	*Homo sapiens*
A dog	*Canis familiaris*
A housefly	*Musca domestica*
Domestic cat	*Felis domesticus*
Maize	*Zea mays*
Bean	*Phaseolus vulgaris*
Lion	*Panthera leo*

To summarise, living things are classified and named for the following main reasons:

1. To create an internationally accepted way of referring to a particular living thing.
2. To avoid confusion created by different languages.
3. To help in simplifying classification and study of living things.

The names we use for organisms are their binomial names – but to reach those names, the organism needs to be completely classified from the kingdom downwards. Here are some examples:

Table 5.2 *Hierarchy of groups*

	Human	Honeybee	Teff	Mushroom
Kingdom	Animalia	Animalia	Plantae	Fungi
Phylum	Chordata	Arthropoda	Angiospermophyta	Basidiomycot
Class	Mammalia	Insecta	Liliopsida	Basidiomycetes
Order	Primates	Hymenoptera	Cyperales	Agaricales
Family	Hominidae	Apidae	Poaceae	Agaricaceae
Genus	Homo	Apis	Eragrostis	Agaris
Species	sapiens	mellifera	teff	campestris

Classifying living organisms

You may have come across organisms that you did not recognise and could not classify. How did you solve this problem? You may have used their common names or searched for their pictures in books. As you have seen, we classify living organisms by looking at the things that are similar between them, and also the things that are different. When you find a strange organism, how do you know which group it fits into?

In this section of the book, you are going to learn how to put organisms into groups and how to use – and build up – a classification key.

To make it as easy as possible to sort organisms out – particularly when you are out in the field – biologists have developed a special method known as a biological key or identification key.

The simplest type of identification key is the **dichotomous key** (*di* means two and *chotomous* means branching). Therefore, a dichotomous key is a type of key that is based on making successive choices between two statements or alternatives.

The statements are descriptions of the external features of specimens. In this section you are going to look at how dichotomous keys are constructed and how they are used to identify unknown specimens. The easiest way to understand how these keys work is to use one that is very straightforward.

KEY WORDS

dichotomous key *a type of key based on making choices between two statements or alternatives*

The example you have here involves some very well-known living organisms to help you understand the process.

As you use these keys, you can see how important it is to have the right questions. You must be able to answer 'Yes' or 'No' to the questions, and the questions asked must separate and identify the animals clearly. For example, in the key below, it is the fact that the cheetah has patterned fur that is not striped that is important – you don't need to ask if it has spots!

Activity 5.1 Identifying organisms using a simple key

In figure 5.3 you can see five big cats. Even if you know the names of these animals, use the keys to identify them fully and write down the correct identification. Add the names in your own language as well!

1. Animal with patterned fur: go to 2.
   Animal with plain fur: go to 3.
2. Animal with stripes: *Panthera tigris* (tiger).
   Animal without stripes: go to 4.
3. Animal is black: *Panthera onca* (black panther).
   Animal is not black: *Panthera Leo* (Lion).
4. Animal has a very short tail: *Lynx lynx* (lynx).
   Animal does not have a very short tail: *Acinonyx jubatus* (cheetah).

***Figure 5.3** Identification using a simple key*

Activity 5.2: Using classification keys to identify common organisms

Materials

Collect five different organisms locally – these might be plant leaves, such as sweet potato, teff, rose, cassava or maize, and some animals, such as a grasshopper or spider. Make a classification key to identify these organisms as accurately as you can. You may need a hand lens to help you look for small features.

Summary

In this section you have learnt that:

- Scientists classify organisms to make the living world easier to understand.
- A species is a group of living organisms that are able to breed successfully with one another and produce fertile offspring.
- Taxonomy involves dividing living organisms into smaller and smaller groups based on features they have in common.
- The binomial system of nomenclature was developed by Carl Linnaeus.
- You can classify living organisms using simple keys.

Review questions

Select the correct answer from A to D.

1. Which of these statements is not a reason why biologists classify the living world?
   A to simplify their study
   B to bring order out of chaos or confusion
   C to try to understand how life originated
   D to make things sound complicated
2. Which of the following great biologists developed the system of naming organisms that we use today?
   A Aklilu Lemma
   B Charles Darwin
   C Carl Linnaeus
   D Tilahun Yilma
3. *Homo sapiens* is the scientific name of which animal?
   A honey bee
   B human being
   C teff
   D lion

KEY WORDS

prokaryotic cells *single-celled organisms without a separate nucleus*

eukaryotic cells *single-celled organisms with a nucleus*

dinoflagellates *microscopic single-celled organisms that cause bioluminescence in the sea when they produce a green light*

5.2 The five kingdoms

By the end of this section you should be able to:

- Explain the five-kingdom classification system.
- Describe the kingdoms of the Monera, Protista and Fungi and give examples of organisms from each one.
- Describe the kingdom Plantae and explain its major divisions, giving examples.
- Classify angiospermes into monocots and dicots and explain the differences between them.
- Describe the kingdom Animalia and explain its major phyla, giving examples.
- Group animals into vertebrates and invertebrates and explain the differences between them.
- Classify the vertebrates into five classes and give examples of each.

As you learnt in section 5.1, the system that scientists use for classifying living things is known as the natural classification system. Living things are put into groups called taxa based on their similarities and differences. The main taxa are kingdom, phylum (division for plants), class, order, family, genus and species. You are going to look at some of these taxonomic groups in more detail and learn the main characteristics of our classification system.

What is a kingdom?

A kingdom is the largest taxon and consists of all the other taxa. In the modern classification, there are five kingdoms namely:

1. Monera (bacteria)
2. Protista (also known as the protoctista)
3. Fungi
4. Plantae
5. Animalia

This system of classification is known as the five-kingdom system. For several centuries scientists worked with a two-kingdom classification (Animalia and Plantae) and a three-kingdom classification (animals, plants and others). There were always a lot of problems with classifying organisms such as bacteria, *Euglena* and fungi. As biologists have discovered more and more organisms, and understand much more about the internal structures of their cells, most of them agree that a classification system with five kingdoms makes the most sense.

Viruses are not classified in any of the above kingdoms. They are grouped separately, as you will see. This is because viruses do not have all the seven characteristics of life, although most scientists now classify them as living organisms.

Figure 5.4 *Colour-enhanced scanning electron micrograph of* Staphylococcus aureus. *These are bacteria commonly carried on the skin or in the nose of healthy people and one of the most common causes of skin infections.*

Kingdom Monera

The Monera include all of the bacteria, as well as the blue-green algae. The members of the kingdom are all single-celled organisms that do not have a separate nucleus (they are **prokaryotic**). They are all microscopic and they reproduce by simply splitting in two. Some of them can make their own food by photosynthesis, but many of them are heterotrophic – they rely on other organisms to provide their food.

Examples include *Mycobacterium tuberculosis*, the bacterium that causes tuberculosis, and *Haemophilus ducreyi*, the bacterium that causes chancroid, as well as all the other bacteria that act as pathogens. Bacteria that do good include those in the soil and in your gut, and those which are involved in the carbon and the nitrogen cycle and in all the processes of decay.

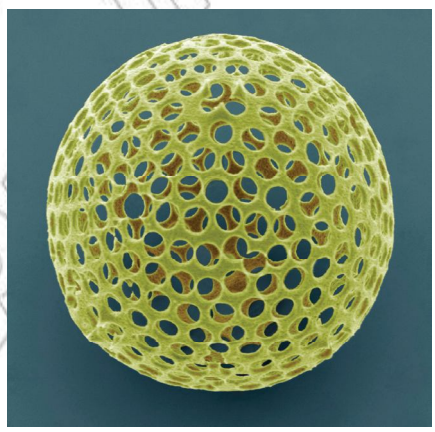

Figure 5.5 *Protista like this radiolarian have complex silica shells and are part of the plankton in the oceans.*

Kingdom Protista

The protista are all microscopic single-celled organisms that do have a nucleus – they are **eukaryotic cells**. They can be quite complex in their shapes. They include plant-like organisms that can move around and animal-like organisms that cannot move. Protista make up much of the plankton found in the oceans and are the basis of the food supply for all the organisms in the sea. Some protista cause serious disease in human beings.

Examples of harmful protista include *Plasmodium falciparum*, which causes malaria, *Entamoeba histolyca*, which causes amoebic dysentery, and *Trypanosoma*, the blood parasite that causes sleeping sickness. **Dinoflagellates** are protista that cause bioluminescence in the seas and oceans when they produce a greenish light.

Activity 5.3: Looking at protista under the microscope

You will need:

- microscope
- prepared slides of protista or
- pond water
- microscope slides
- cover slips

Method

Use your microscope with care, as you learnt in unit 2.

Either use prepared slides to look at different protista and draw them, or make a slide from a drop of pond water and look for protista such as amoeba moving about.

Activity 5.4: Looking at fungi

You are going to look at and draw several different types of fungus. Some of them may be quite big, but you may want to use a microscope to look at some of them. If necessary you can grow your own fungi on a little damp injera or by letting a piece of fruit go rotten. You can collect lichen from the trees to examine and draw as well.

KEY WORDS

saprotrophs *organisms that feed off dead material*

mutualists *organisms that live in close association with each other and both benefit from this association*

mycorrhizae *organic association between a fungus and the roots of a plant*

bryophyta *plant division consisting of mosses and liverworts*

liverworts *small, green nonvascular plant growing in wet places*

Figure 5.6 *Fungi are very important – they do a lot of good but can also cause harm.*

Kingdom Fungi

For many years the fungi were classified as a sort of plant. However, fungi cannot make food by photosynthesis so they do not really fit in the plant kingdom. Now the great differences between fungi and true plants are recognised, the fungi have a kingdom of their own. The fungi are a large and very successful group – there are around 80 000 species. They vary in size from single-celled yeasts to enormous puffballs.

Fungi are eukaryotic and usually multicellular. They are heterotrophic, either absorbing nutrients directly from their food or secreting enzymes to digest their food outside the fungus and then absorbing the nutrients. Many fungi are **saprotrophs**, which means they feed on dead material. Saprophytic fungi usually produce huge numbers of spores, which float on the wind to other dead material. They play a vital role within ecosystems as decomposers. Examples of this type of fungus are *Rhizopus* (bread mould), *Mucor* and *Penicillium* (the fungus that produces the antibiotic penicillin).

Fungi can be parasites, feeding on living organisms. They attack plants more than animals, although some fungi, such as *Candida albicans* (thrush) and *Tinea pedis* (athlete's foot) affect people and other animals. Fungal parasites such as the mildews cause enormous damage to plants. Some fungi are **mutualists**. This means they live in close association with another organism and both benefit. Examples are lichens, which are a combination of a fungus and green algae or blue-green bacteria, and **mycorrhizae**, an association between a fungus and the roots of a plant. Yeast, which makes injera rise and allows us to make alcohol, is one of the few single-celled fungi.

Activity 5.5: The first three kingdoms

Develop a table that simplifies and summarises the first three kingdoms as follows. Copy the example shown here and fill it in.

Kingdom	Characteristics	Examples
Monera		
Protista		
Fungi		

Kingdom Plantae

The kingdom Plantae – the plants – includes a great variety of organisms, which range from tiny mosses to giant trees. So far botanists have identified around 300 000 living plant species, and over 80% of these are flowering plants.

Plants are enormously important – they are the source of the fossil fuel coal and through photosynthesis they provide food and oxygen for all other living organisms. We human beings use plants to provide us with food, building materials, clothing, medicines and many other things.

The main characteristics of all plants include:

- They have eukaryotic cells.
- They are multicellular organisms.
- They contain chlorophyll and carry out photosynthesis.
- They are predominantly land dwelling.
- Most have a waxy cuticle that helps to prevent drying out.

The kingdom Plantae consists of non-flowering plants and flowering plants. The kingdom is split into a number of divisions. Plant divisions are the same as animal phyla. The four most important divisions are:

Bryophyta – the **mosses** and **liverworts**

Pteridophyta (also known as the Filicinophyta) – the **ferns**

Gymnospermae (also known as the Coniferophyta) – the **conifers**

Angiospermae (also known as the Angiospermophyta) – the true flowering plants

KEY WORDS

mosses *nonvascular plants with a single stem and leaves of only one cell thickness*

pteridophyta *plant division consisting of ferns*

ferns *plants of damp shady places*

gymnospermae *plant division of conifers*

conifers *evergreen plants with needle-shaped leaves whose reproductive structures are found in cones*

angiospermae *true flowering plants*

rhizoids *simple root-like structure of mosses*

Figure 5.7 *Our forests have an amazing variety of plant life.*

Division Bryophyta (mosses and liverworts)

Bryophytes are the simplest land plants. They do not have a true root system so they cannot reach water under the soil or anchor themselves very firmly to the ground. They are non-vascular (do not have xylem and phloem) and so cannot transport food or water around the body of the plant. They are small – the largest species is less than 60 cm tall – and are found in damp places. A large percentage of bryophytes live in tropical rainforests.

The best examples of bryophytes are mosses like *Etodon concinnus*, found in the Bale Mountains, and *Funaria* spp. A moss plant has a simple, slender stem. They also have thin simple leaves, which are only one cell thick (and therefore useful for looking at under a microscope). Mosses also have simple root-like structures called **rhizoids** that have slender filaments and attach the mosses to the soil but without any strength. The other example is the liverworts, which only grow in very wet places. Bryophytes are commonly found in rainforests and at high altitudes on mountains.

Figure 5.8 *Mosses like this can be found in damp places in Ethiopia.*

Activity 5.6: Looking at mosses

You will need:

- mosses, e.g. *Funaria*
- microscope
- hand lens
- scalpel blade
- forceps
- microscope slide and cover slip

Method

1. In groups, search around the school for moss plants around damp walls, rocks, tree bark or damp verandas. Carry your collected specimen into the laboratory for detailed study.
2. With the help of a hand lens, examine the specimen carefully and identify the parts.
3. Draw and label your specimen.
4. Carefully detach one leaf from the moss plant and mount on a clean glass slide. Examine under low power and observe the arrangement of the cells.
5. Mount the rhizoids on a slide and view under low power and observe the arrangement of the cells.
6. Using forceps or a needle, remove a capsule if you can see one, mount it on a slide and view under low power. Draw what you see.
   - What does a capsule contain?
   - In what respects is a moss plant more complex than an alga or fungus?

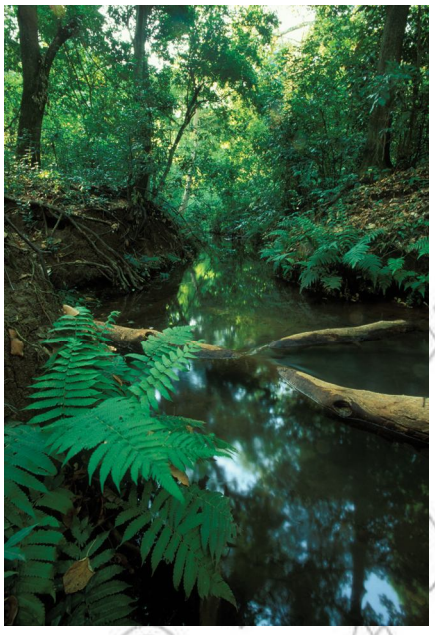

Figure 5.9 *Ferns can transport water and food around their bodies, which means they can grow in a much wider range of places than mosses can, but many of them still prefer damp and shade.*

Division Pteridophyta

In this division the plants have true leaves, stems and roots. Fern stems have **rhizomes**, which grow horizontally just below the surface of the soil. Their stems contain vascular tissue similar to that found in flowering plants, and so do their roots. They produce spore-forming bodies on the underside of the fronds. The spores are dispersed by wind. However, they still rely on water for reproduction, which limits where they can live.

Most ferns live in damp, shady places – they are very common in tropical rainforests where conditions are ideal for their growth. However, some ferns – such as *Pteridium* spp (commonly known as bracken) – are an exception because they can grow and do well in full sunlight.

Another example of a pteridophyte is the fern *Dryopteris* spp. There are a number of different *Dryopteris* ferns in Ethiopia, and *Dryopteris concolor* is a recently discovered one.

The next two divisions of the plants that you are going to look at are the seed-bearing plants or **spermatophytes**. These are the most successful of all land plants. They form the most common plants on earth. Spermatophytes are the most successful because of the following characteristic features that they possess:

- They have well-developed roots, stem and leaves.
- They have well-developed vascular tissues.
- The male gametes are contained within pollen grains and the female gamete is contained within the embryo sac.

Activity 5.7: Examining a fern

You will need:

- a common fern
- hand lens
- scalpel
- clean slide
- cover slip
- microscope

Method

1. In groups, search for a fern along rivers/stream banks, shady areas beneath trees and fences.
2. Examine your specimens and identify as many structures as you can.
3. Draw and label your specimen.
4. Observe the lower surface of the leaves (fronds).
5. Draw the lower surface of the specimen showing the arrangement of the spore-forming bodies (sori) if there are any there.
6. Use a scalpel to transfer some of the sori onto a slide and examine them under low power and draw.

- The product of fertilisation in sexual reproduction is a seed that may or may not be enclosed in a fruit.

The spermatophyta are divided into two divisions, namely, gymnospermae and angiospermae.

KEY WORDS

rhizome *root which grows horizontally just below the surface of the soil*

spermatophytes *seed-bearing plants*

Division Gymnospermae

These are more commonly known as the conifers or 'naked seed plants'. Pine trees, spruces and cedars are just some of the more common conifers. They grow around the world – about one third of the world's forests are coniferous – and are often cultivated for timber as some of them are relatively fast growing. They are usually the dominant vegetation in cold and mountainous regions. Some conifers have developed relatively fleshy tissue around their seeds (e.g. juniper and yew), but the majority produce bare cones. The main characteristics of the gymnospermae are:

- Their seeds are not enclosed in fruits.
- They have small needle-shaped leaves with a thick waxy cuticle that reduces water loss and minimises damage by excess heat or cold.
- They are evergreen so they can photosynthesize all year long.
- The reproductive structures are found in cones.

Figure 5.10 *Gymnosperms have very typical leaves and cones with naked, exposed seeds.*

A conifer tree produces two different types of cone. The male cone forms huge numbers of pollen grains that are blown by wind to a female cone. Fertilisation results in a small winged seed.

The genus *Pinus* (for example, *Pinus sylvestris*, *Pinus resinosa*, *Pinus radiata*) is a good example of a conifer. Members of this genus grow all around the world. They are evergreen – they maintain their leaves throughout the year, even in temperate climates. This means they shed and replace a few leaves all the time rather than spending part of the year leafless and dormant.

Activity 5.8: Examining conifers

You will need:

- conifer leaves and cones

Method

1. Obtain some conifer leaves and cones.
2. Observe them carefully.
3. Make large well-labelled drawings of the leaves of the conifer.
4. Examine some conifer cones. Note the seeds attached to the cone. Carefully remove one seed from the cone of the conifer and draw it.

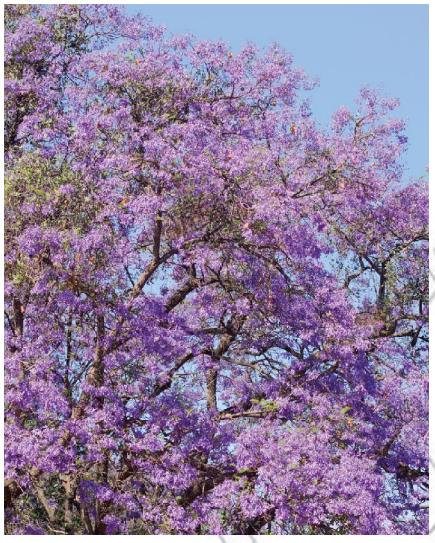

Figure 5.11 *Flowering plants are all around us. They are the most successful plants.*

KEY WORDS

xylem *dead transport tissue in plants, moving water and minerals*

phloem *living transport tissue in plants that transports food around*

Conifers have been imported and planted in East Africa because of their importance as a source of timber and for ornamental purposes. Look for some conifers around homes, schools, hotel compounds and other places where trees are commonly found.

Division Angiospermae

The flowering plants are the biggest group of land plants on the Earth. Their reproductive structures are carried in flowers. The biggest flowers in the world belong to *Rafflesia arnoldii* and they can be as much as a metre across. The smallest belong to *Wolffia globosa* and they are less than 2 mm across. Whatever the size of the flowers, they carry the reproductive parts of the plant. The main characteristics of the angiosperms are:

- They have flowers as reproductive organs.
- They have their seeds enclosed in a fruit.
- They have well-developed **xylem** and **phloem** tissue.

Subdivisions of angiosperms

Angiosperms are subdivided into two main classes according to the number of cotyledons they have in their seeds. These classes are **monocotyledons** and **dicotyledons**.

Class Monocotyledons (monocots)

The monocotyledons (monocots) are a group of enormous importance because the cereal plants that form the staple diet of most of the world's population are monocotyledons. So are the grasses that feed domestic herbivores, which supply so many cultures with meat and milk. The grasses also feed many of the large wild herbivores such as zebra, wildebeest and the many different types of antelope that live in Ethiopia and beyond. The main characteristics of the monocotyledons are:

- The embryo has a single seed leaf (cotyledon).
- Leaves are generally long and thin with parallel veins.
- The stem contains scattered vascular bundles.
- In general, monocots do not reach great sizes (palms are the exception to this).
- They are often wind pollinated.

Common examples of monocot plants include the grasses, orchids and maize. Maize (*Zea mays*) has been used for food and animal fodder by people for centuries. Teff is another example of a monocotyledonous plant.

Class Dicotyledons (dicots)

The dicotyledoneae (dicots) make up most of the trees with which we are familiar, as well as many vegetable plants in our gardens and almost all of the coloured flowering plants in the world. The main characteristics of the dicotyledons are:

- The embryo has two seed leaves (cotyledons).
- The leaves are often relatively broad and have a network of veins.
- The stem contains a ring of vascular tissue.
- Some dicots reach great sizes.
- They are often insect pollinated.

Some common examples of dicots include sunflowers, peas, roses and beans. Most trees, such as *Jacaranda*, *Eucalyptus*, *Cassia* and mangos are dicotyledons. Shrubs include *Hibiscus*, *Lantana camara*, *Bauhinia* and oranges.

Figure 5.12 *Close-up of a chard leaf, showing the network of veins.*

Activity 5.9: Examining a dicotyledonous plant and a monocotyledonous plant

You will need:

- bean plant with flowers and bean seed
- maize plant with flowers and maize grain (or any other specimens available in the locality)
- hand lens

Method

1. Obtain a bean plant and a maize plant (or any other specimens available in the locality).
2. Compare their roots, stems, leaves, flowers and seeds.
3. Make a table of differences between the bean plant and the maize plant.
4. Draw well-labelled diagrams of the bean plant and the maize plant.
5. Make a collection of plants around your school. Identify them and then classify them according to whether they are monocotyledons or dicotyledons.

Activity 5.10: From bryophytes to angiosperms

Develop a table that simplifies and summarises the divisions from mosses to flowering plants as follows. Copy the example shown here and fill it in.

Division	Characteristics	Examples
Bryophyta		
Pteridophyta		
Gymnospermae		
Angiospermae (including monocots and dicots)		

KEY WORDS

monocotyledons *any flowering plant having a single cotyledon (leaf) in the seeds*

dicotyledons *flowering plants with two embryonic seed leaves*

Kingdom Animalia

This kingdom includes the animals. There are at least two million species of animals alive today. Animals are multicellular and heterotrophic – they feed on other organisms. They differ from the members of the other four kingdoms in that they exhibit locomotion, that is, can move their bodies from one place to another, and their cells do not have cell walls. They have nervous systems so they are sensitive to their surroundings. There are 33 animal phyla, but here we shall only consider the main ones.

- **Porifera** (sponges)
- **Coelenterata** (cidaria)
- **Platyhelminthes** (flatworms)
- **Nematoda** (roundworms or nemathelminthes)
- **Annelida** (segmented worms)
- **Mollusca** (soft-bodied animals)
- **Echinodermata** (spiny-skinned animals)
- **Arthropoda** (joint-footed animals)
- **Chordata**

The first eight phyla are also called invertebrates. This means they do not have a backbone. The phylum Chordata includes the vertebrates – all the animals which have a spinal cord enclosed in a backbone of vertebrae. We shall consider the main features of each of these phyla.

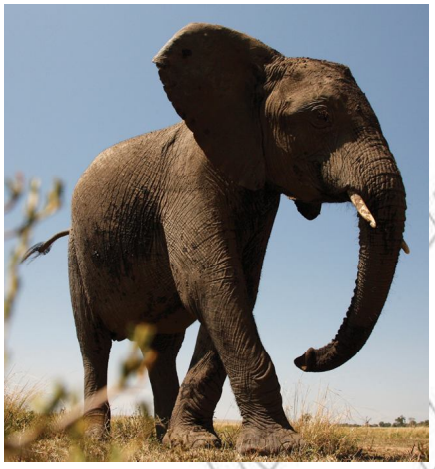

Figure 5.13 *Animals come in many different shapes and forms but they are all multicellular heterotrophs.*

Figure 5.14 *Sponges do not look much like animals, but that is what they are.*

Phylum Porifera – the sponges

The sponges are the simplest invertebrates. Only the young move about – the adults are permanently attached to a surface on the sea bed. They are hollow filter feeders, and the body cavity is connected to its external environment by pores. There is little co-ordination or control. They range in size from a few millimetres to two metres and are supported by a series of calcareous spicules. As far as is known, the sponges are an evolutionary dead end and have no other close living relatives.

Phylum Coelenterata

The coelenterates include some exceptionally beautiful creatures and also some very poisonous ones. Sea anemones, hydra, jelly fish and coral are among the members of this phylum. They have soft bodies with a ring of tentacles for capturing prey. They have stinging cells on their tentacles for poisoning or immobilising prey and predators. Coelenterates have two layers of cells in their bodies that surround a central cavity. They have only one opening, the mouth, and their bodies have radial symmetry.

Figure 5.15 *Coelenterates range from tiny coral polyps and hydra to enormous jelly fish.*

Phylum Platyhelminthes – flatworms

The flatworms show a relatively high level of organisation. They range from 1 mm to 30 cm in length. They possess a front end where the mouth, major sense organs and the main integrating region of the nervous system is sited. They have flattened bodies with a mouth but no anus. They have no body cavity and rely on diffusion for everything. They are hermaphrodites – they contain both male and female sex organs. They live in other animals as parasites or are free-living in fresh water.

Examples of platyhelminthes include *Planaria* spp, which live in fresh water, tapeworms and liver flukes like *Fasciola hepatica*.

Figure 5.16 *Like* Taenia, *which you met in unit 4, the liver fluke* Fasciola hepatica *can cause problems both for livestock and humans.*

Activity 5.11: Looking at porifera, coelenterata and platyhelminthes

You will need:

- preserved or fresh specimens of porifera, coelenterata and platyhelminthes
- hand lens

Method

Observe, draw and label specimens of these invertebrate phyla.

Activity 5.12: Looking at nematodes

You will need:

- sample of moist soil or water from the bottom of a pond
- hand lens

Method

Observe and then measure, if possible, draw and label specimens of nematode worms.

Phylum Nematoda (nemathelminthes) – roundworms

Roundworms are thought to be the most numerous animals in the world. It has been estimated that there are around 5 billion roundworms in the top 7 cm of an acre of soil. They are found in almost all environments, from the deepest ocean floor to the Antarctic! Nematodes have narrow, thread-like bodies, which are pointed at both ends and bilaterally symmetrical. Their bodies are not segmented and are round in cross-section, which is how they get their name. They don't have a circulatory system but they do have a complete digestive system with both mouth and anus.

The phylum contains many important parasites, such as *Ascaris*, which infects the guts of both humans and pigs, and the family Filariidae, which cause elephantiasis affecting the lives of up to 1.2 billion people in Africa and Asia. Nematodes are also a very important part of a healthy soil.

Figure 5.17 *Nematodes or roundworms are vital for healthy habitats, yet they cause diseases of many plants and animals as well.*

KEY WORDS

chaetae *bristle-like structures that help segmented worms to move*

tube feet *used by echinoderms to move around*

Figure 5.18 *Earthworms are one of the best-known examples of the annelid worms all over the world.*

Activity 5.13: Looking at annelida

You will need:

- sample of moist soil or compost from a compost heap
- hand lens

Method

Observe and then measure, if possible, draw and label specimens of annelid worms.

Figure 5.19 *Molluscs are a very varied group of animals. This giant East African land snail carries its protective shell on its back.*

Phylum Annelida

The annelid or segmented worms have a body divided into regular segments with structures and organs repeated along the body. They have a closed blood circulatory system. They are hermaphrodites, with male and female reproductive organs and they have bristle-like structures called **chaetae** to help them move. They are found in moist soil and water and most are free-living. The common earthworm, *Lumbricus terrestris*, is a good example. Earthworms are very important because they increase the fertility of the soil. *Hirudo* spp, the medicinal leech, is another example of an annelid worm.

Phylum Mollusca

The molluscs have a wide range of lifestyles and include the most intelligent of the invertebrate species. Octopi and squid have well-developed brains. They may have shells or be shell-less, live in the sea, or in fresh water or on land. The main features of the molluscs include a soft muscular foot with a soft body, which is often protected by the shell. Their bodies are divided into head, foot and visceral mass and they are not segmented. They breathe through gills. Examples of molluscs include slugs and snails like the giant East African land snail (*Achatina fulica*), bivalves like *Mytilis* spp, the marine mussel and octopuses and squids.

Activity 5.14: Looking at mollusca

You will need:

- molluscs, e.g. *Achatina fulica*, any other local slug or snail
- hand lens
- glass beaker

Method

Observe and then measure, if possible, draw and label specimens of molluscs.

Observe carefully how the animal moves. Putting it in a glass beaker allows you to see the underneath of the muscular foot and watch the waves of muscle contraction as it moves along.

Phylum Echinodermata

The sea urchins, starfish and brittle stars make up this phylum of invertebrates. The skin contains many spines. Although they appear very simple they have a mouth (on the lower side), a gut and an anus (on the upper side). They are all marine animals, and move around using **tube feet**. The adults have five arms, but the larval stages do not. Examples include *Asteris*, the common starfish, *Echinus*, the common sea urchin and *Paracucumana tricolor*, a brightly coloured sea cucumber known as a sea apple.

Phylum Arthropoda

This phylum gets its name from two Greek words, *arthron* – joint, and *podos* – foot. The arthropods are the most varied animals on the Earth, with around a million different species. They have made use of a wide range of available ecological niches. However, they cannot grow very large. They have an external exoskeleton made of chitin that prevents excessive water loss but also limits their growth. Arthropods are animals with segmented bodies and jointed limbs. They have a well-developed nervous system and a complete gut from the mouth to anus.

The phylum Arthropoda is divided into a number of classes according to the number of limbs, presence and number of antennae and number of body parts. These include **insecta**, **crustacea**, **arachnida**, **diplopoda** and **chilopoda**.

The insecta live almost everywhere, although most are land-based. They have a body divided into three body parts; head, thorax and abdomen. They have three pairs of jointed legs on the thorax along with one or two pairs of wings. On their head they have a pair of antennae and one pair of compound eyes. Insects include flies, butterflies and moths, beetles, wasps and bees and many other common groups.

The crustacea are mainly aquatic. They vary in size from very small, for example water fleas, to quite large, for example lobsters and crabs. The body is made up of two parts – a cephalothorax (head fused with thorax) and abdomen. The body is often protected by a tough covering called a carapace. They have more than four pairs of jointed legs, two pairs of antennae and simple eyes. In some members, the eyes are on stalks. Crustaceans include *Daphnia*, crab, prawn, shrimp, barnacle, water flea, lobsters, woodlice and crayfish.

The chilopoda – the centipedes – and the diplopoda – the millipedes – are often confused. In fact some scientists put them all in one group. They both have long bodies with many segments and lots of legs! Table 5.3 summarises the differences between them.

***Table 5.3** Differences between centipedes and millipedes*

Centipedes	Millipedes
Have flattened bodies	Cylindrical bodies
Have brightly coloured bodies	Dull-coloured bodies
Have few or less segments	Have more segments
Have one pair of limbs per segment	Have two pairs of limbs per segment
Carnivorous (feed on other animals)	Herbivorous
Have poisonous claws for paralysing their prey	Have claws for biting and chewing plant material

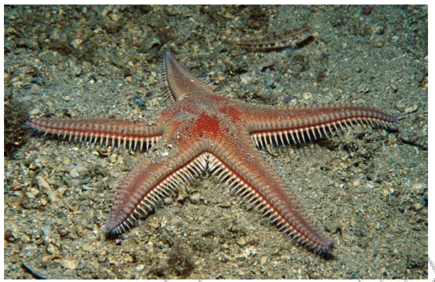

***Figure 5.20** Echinoderms are a relatively small specialised phylum of marine animals.*

KEY WORDS

insecta *insects*

crustacea *aquatic creatures with bodies made up of a cephalothorax and abdomen, four pairs of legs, two pairs of antennae and simple eyes*

arachnida *spiders*

diplopoda *millipedes*

chilopoda *centipedes*

***Figure 5.21** Insects are the best known of all the arthropods, and they come in many shapes and sizes.*

The arachnida (the spiders) are mainly terrestrial although some are aquatic. They have two body parts – a cephalothorax (fused head and thorax) and the abdomen – with no antennae. They have eight legs in four pairs. Arachnids have simple eyes but often up to eight of them. Spiders spin silken webs. Examples of arachnids include spiders, ticks, scorpions and mites.

Activity 5.15: Collecting and examining arthropods

You will need:

- representative specimens of each class, e.g. grasshopper, crab, spider, a tick, a centipede, a millipede, in suitable containers
- a hand lens

Method

1. Obtain representatives of the class of arthropods. You may be given dead specimens or capture live ones. Treat living organisms with respect. You may need to use nets to catch some of the organisms. Make sure that they have access to air and do not get too hot while you have them in the lab.

   Take care handling any organisms which may sting or bite, or may carry disease.
2. What features do your specimens have in common?
3. Examine their characteristic features, i.e. number of limbs, presence and number of antennae and number of body parts, presence and number of wings.
4. Make a table of characteristic features like table 5.4.
5. Make large well-labelled drawings of each of your specimens.

Table 5.4 *Characteristic features of arthropods*

Specimen (examples have been filled in – use the actual examples you find)	**Number of body parts**	**Number of limbs**	**Antennae**	**Wings**
Grasshopper				
Crab				
Spider				
Centipede				
Millipede				

KEY WORD

notochord *flexible rod-like structure of cartilage running along the dorsal side of the body*

Phylum Chordata

The term chordata is derived from the term notochord. A **notochord** is a flexible rod-like structure, made of cartilage, which runs along the dorsal side of the body. It provides support to the body.

Animals in the phylum Chordata have the following three features in common:

- They have a notochord at some stage of their lifecycle.
- They have a hollow nerve cord, which is a group of nerves forming a hollow tube. This is located above the notochord.
- They have gill slits during early stages of development that are later replaced by lungs and gills.

Vertebrates

The invertebrates make up more than 99.9% of the animals alive on earth today. However, if you ask people to name ten animals, most of them would chose ten from the remaining 0.1% – the **chordates**, the best known of which are the **vertebrates**. As the name suggests, vertebrate animals have a vertebral column/backbone. In addition, they also have the following features:

1. An internal skeleton (endoskeleton) made of bone or cartilage.
2. A closed blood circulatory system consisting of blood vessels.
3. A well-developed nervous system.
4. Two pairs of limbs.
5. Kidneys as excretory organs.

Vertebrate animals form the largest group of the phylum Chordata and they are divided into five classes:

- Pisces – the fish
- Amphibia – the amphibians
- Reptilia – the reptiles
- Aves – the birds
- Mammalia – the mammals

KEY WORDS

chordates *creatures characterised by a notochord, nerve chord and gill slits*

vertebrates *creatures with a vertebral column/ backbone*

teleosts *bony fish*

elasmobranchs *cartilaginous fish*

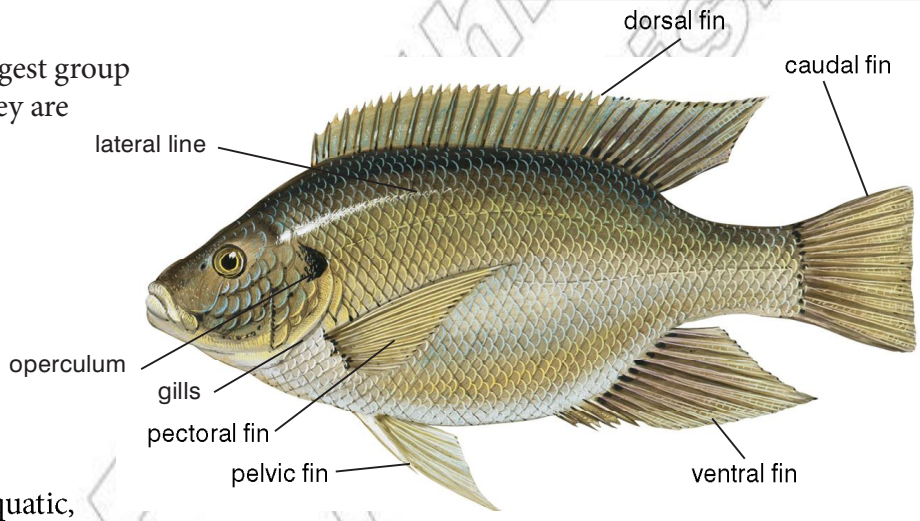

***Figure 5.22** An illustration of a typical bony fish*

Class Pisces

These are the fishes. They are aquatic, i.e. they live in water, except the mudskipper and lung fish, which can spend short periods breathing in air. They have streamlined bodies with scales on their skin. They use gills for gaseous exchange and have fins for swimming. They have a lateral line system for hearing and most fish are dark on the dorsal (back) side and lighter on the ventral side. Fish are ectothermic – they rely on heat from their environment to regulate their body temperature. Fish are important to people the world over as a source of food.

The class Pisces is divided into two subclasses:

- Bony fish (**teleosts**) – examples include *Tilapia*, Nile perch, cod, mackerel and catfish.
- Cartilaginous fish (**elasmobranchs**) – examples include sharks, skates and rays.

The main differences between the two groups are summarised in table 5.5.

***Table 5.5** Differences between bony fish and cartilaginous fish*

Bony fish	Cartilaginous fish
Have bony skeleton	Have cartilaginous skeleton
Have round-shaped scales	Have scales that are not round shaped
Have opercula (gill covers) covering their gills	Have no opercula (gill covers) but have gill slits
Have homocercal tails (even size fins)	Have heterocercal tails (one part is larger than the other)
Are usually smaller in size	Are usually larger in size

Activity 5.16: Examining a bony fish

You will need:

- freshly killed bony fish, e.g. *Tilapia*, Nile perch
- dissecting board
- dissecting kit

Method

1. In groups of five, examine the external features of the bony fish.
2. Using figure 5.22 as a guide, identify the following parts:
   dorsal fin, caudal fin, ventral fin, pectoral fin, pelvic fin, lateral line, scales, operculum
3. Make a large and well-labelled drawing of the bony fish as seen from the side. Label all the structures you have identified.

KEY WORD

amphibian *creatures who spend part of their lives in water and part of it on land*

Class Amphibia

This class includes the amphibians (frogs, toads, newts and salamanders). The word **amphibian** comes from two Greek words *amphi*, which means both, and *bios*, which means life. This means that amphibians spend part of their lives (as larvae or tadpoles) in water and part of it (as adults) on land.

The amphibians were the first vertebrates to colonise the land. They have simple sac-like lungs (which are not very efficient) and smooth, moist skin, which is also used as a respiratory surface. Their lifecycle includes metamorphosis, and they need water for successful reproduction as fertilisation is external and the larval form (tadpole) is aquatic. Gills are only present in the larval forms. Amphibians are ectothermic – they rely on heat from their environment to regulate their body temperature. Worldwide there are many concerns about the survival of the amphibian class, because a pathogenic fungus has emerged that is killing them in their millions, driving species to extinction particularly in the Americas and Australia. Combined with the loss of habitat that is also occurring and the pollution, which is becoming a problem all over the world, scientists are very worried about the future of amphibians. There is a genus of toads containing two species known as Ethiopian toads (*Altiphrynoides*), which are found mainly in the mountains in the south and centre of our country.

***Figure 5.23** The Ethiopian banana frog,* Afrixalus enseticola, *is tiny and, like many amphibians, vulnerable to extinction.*

Activity 5.17: Examining the external features of a frog or toad

You will need:

- a live or freshly killed toad or frog (The live toad/frog should be kept in a transparent container or cage.)
- a pair of forceps
- a pair of gloves

Method

1. Examine the head and trunk regions of the toad. Note and identify the following characteristic features:
    - Mouth – has a wide gape. With the help of forceps, open the mouth and note the long sticky tongue, which is used to capture insects, and homodont teeth, i.e. same-sized teeth (dead specimen only).
    - Nostrils – two small holes situated above the mouth to enable breathing while partly submerged in water.
    - Eyes – large and bulging; move the eyelids with your forceps. Are both eyelids movable and opaque? (Dead specimen only.)
    - Ears – are dark, round patches behind the eyes; there is no external ear.
    - Poison glands (toads) – elongated swellings behind the ears, which secrete a detestable milky substance when the toad is attacked.
    - Trunk – in toad note the dark, rough and dry skin on the dorsal side and lighter and less rough skin on the ventral side of the trunk; in frog: smooth moist skin.
    - Limbs – these are found on the trunk; note that the hindlimbs are longer and thicker than the forelimbs. The hindlimbs are used for leaping, whereas the short stout forelimbs help to absorb the shock on landing. The webbed digits give additional thrust during swimming. Which of these limbs are webbed?
    - Does your toad/frog have a tail?
2. Make a large well-labelled drawing of the toad/frog as seen from the side.

Table 5.6 will help you discover which features to look for if you have a toad or a frog – many people are confused about the differences between them.

***Table 5.6** Differences between a frog and a toad*

Frog	Toad
Has a smooth skin	Has a rough skin
Has a moist skin	Has a dry skin
Has more webbed feet	Has less webbed feet
Has a brightly coloured body	Has a dull-coloured body
Has a more streamlined body	Has a less streamlined body
Has extra-long hind legs	Has hind legs that are not extra long

KEY WORD

reptiles *cold-blooded, usually egg-laying, vertebrates*

Class Reptilia

The **reptiles** are mainly terrestrial animals that were for many millions of years the dominant group of animals on the Earth. They have dry skin with scales and their gas exchange takes place exclusively in the lungs. They have developed internal fertilisation

Figure 5.24 *The Ethiopian crocodile is one of the larger reptiles and it shows all the typical features of the group. Many other types of reptile are much smaller!*

KEY WORDS

wings *forelimbs of birds adapted for flying*

endothermic *creatures who use heat produced by their own metabolism to regulate their body temperature*

mammals *creatures who produce milk for their young, have a high internal body temperature and regulate their own body temperature*

and they lay eggs on land in a leathery shell. Some reptiles even keep the eggs within their body and give birth to fully developed young. These reproductive developments freed the reptiles from the need to return to the water to breed and so have enabled them to colonise dry and hot environments. As a result, reptiles are found in many areas of the world. The gill slits that are a chordate feature are seen only in embryonic development in the reptiles, and reptiles have no external ears. Reptiles are ectothermic – they rely on heat from their environment to regulate their body temperature. Examples include snakes, crocodiles, such as the Ethiopian crocodile, a subspecies of the Nile crocodile known as *Crocodyus niloticus niloticus*, and lizards, for example, the East African spiny-tailed lizard, *Cordylus tropidosternum*.

Class Aves

These are the birds. Birds have feathers over most of their body, and scales on their legs. The forelimbs are adapted as **wings**, which most birds use to fly. The sternum or breastbone has been enlarged into a big keel shape for the attachment of the wing muscles, particularly in those birds that fly. This forms the tasty meat that is so good to eat! The jaws are toothless and are covered by a horny beak. Birds reproduce using well-developed eggs with a hard shell and in many cases the parent birds spend a lot of time and effort raising their young. Birds have light skeletons, which makes it easier for them to fly. They are also **endothermic**, which means they use heat produced by their own metabolism to regulate their body temperature. Of the main chordate features, only the hollow nerve cord remains in an adult bird, although the others can be seen at stages during the development of the embryo in the egg. Examples include domestic fowl, the wattled ibis (*Bostrychia carunculata*), white collared pigeon (*Columba albitorques*) and the Ethiopian eagle owl (*Bubo capensis*).

Examine the bird provided in the following activity to discover as many of the characteristics of birds as you can.

Activity 5.18: Examining a bird

You will need:

- a stuffed or preserved specimen of a bird, a live pet bird or domestic fowl or a freshly killed domestic fowl
- dissecting board

Method

1. Carefully examine the domestic fowl provided.
2. Identify as many of the different parts as you can.
3. Make a large well-labelled drawing of the fowl.

Figure 5.25 *Birds are the only group of vertebrate animals which can almost all fly. Their bodies are specially adapted to make this possible.*

Class Mammalia

Mammals are the best known of all animals. Mammals differ from other chordates in a number of ways. A true mammal produces milk for its young in mammary glands, has a high internal body temperature and regulates its own body temperature. Mammals sweat to help control their body temperature. A mammal has hair on the skin and external ears. Most mammals also produce live young which have developed for a time within the body of the mother in a structure called the uterus. As with the birds, chordate features are only plainly visible in the embryos. The mammals range in size from tiny shrews to elephants and whales. The ways in which they control their body temperature and reproduce inside their bodies have made it possible for them to live almost everywhere on the earth. We human beings are just one example of this most highly developed phylum of animals.

In the following activity you will examine a typical mammal to find out the characteristic features of mammals.

Subdivisions of mammals

Mammals are classified according to the way their young are produced. There are three sub-classes of mammals:

- Egg-laying mammals – lay eggs, e.g. duck-billed platypus.
- **Marsupials** – produce immature young, which are nourished by milk in the pouch, e.g. kangaroo, koala bear, opossum.
- Higher mammals – produce fully developed young, which are nourished by milk from the mammary glands, e.g. rats, cows, elephants, cats, monkeys and humans.

Mammals are a very successful group of animals, which give us the biggest animals in most of the habitats on the Earth. There are even flying mammals, as bats have been adapted to fly through the air on their leathery wings!

Figure 5.26 *The Ethiopian wolf (*Canis simensis *Rüppell) is a beautiful example of a rare mammal found in our country. It has all the features of a typical mammal and survives in tough conditions.*

Activity 5.19: Examining a small mammal

You will need:

- small live mammal in a cage, e.g. a pet dog, or freshly killed small mammal, e.g. a rat or rabbit
- dissecting board
- forceps

Method

1. If the mammal is alive and tame so it can be handled, get it out to look for the different features. If not, look at it in the cage. If it is dead, place the mammal on a dissecting board.
2. Identify and examine the following features: skin, mouth (open the mouth and examine the teeth), external ear.

   If your specimen is a female, look for the mammary glands.
3. Make a large well-labelled drawing of the mammal showing its external features.

KEY WORD

marsupials *mammals who produce immature young which are nourished by milk in the mother's pouch*

Summary

In this section you have learnt:

- The five-kingdom classification of the living world.
- The characteristic features of the kingdom Monera and examples of typical monerans.
- The characteristic features of the kingdom Protista and examples of typical protista.
- The characteristic features of the kingdom Fungi and examples of typical fungi.
- The characteristic features of the main divisions of the kingdom Plantae – Bryophyta, Pteridophyta, Gymnospermae and Angiospermae with typical examples of each.
- That the Angiospermae are divided into monocots and dicots and how to recognise each type of plant.
- The characteristic features of each phylum of the kingdom Animalia – Porifera, Coelenterata, Platyhelminthes, Nemathelminthes, Annelida, Mollusca, Echinodermata, Arthropoda and Chordata with typical examples of each phylum.
- The characteristic features of the main classes of the phylum Chordata – fish, amphibian, reptiles, birds and mammals with typical examples of each.

Review questions

Select the correct answer from A to D.

1. Which of the following is NOT one of the five kingdoms used to classify the living world?

   A Protista
   B Animalia
   C eukaryota
   D Fungi

2. Which of the following is a characteristic of all members of the kingdom Monera?

   A does not have an enclosed nucleus
   B carries out photosynthesis
   C has a bony skeleton
   D breathes through gills

3. In which of the following plant divisions would you find plants that have no transport tissues and no true roots?

   A Pteridophyta
   B Gymnospermae
   C Angiospermae
   D Bryophyta

4. The following statements describe which phylum of animals?

   They have narrow, thread-like bodies that are not segmented, pointed at both ends, bilaterally symmetrical and round in cross-section. They have no circulatory system but they do have a complete digestive system with both mouth and anus.

   A Mollusca
   B Annelida
   C Echinodermata
   D Nematoda

5. Which class of the vertebrata has scaly skin on the legs, lays eggs and can regulate its own body temperature?

   A birds
   B fish
   C mammals
   D reptiles

End of unit questions

1. a) What does classification mean?
   b) Why is classification so important to scientists?
   c) What is taxonomy?
   d) What do scientists look for when classifying organisms?
2. Investigate the life and work of Carl Linnaeus and write a report on his binomial system of naming organisms.
3. a) What is a dichotomous key?
   b) Explain why dichotomous keys are useful to a scientist.
4. a) Name the five kingdoms in the biological classification system.
   b) State the subdivisions into which these kingdoms are all split.
5. State the kingdom and phylum to which each of the following organisms belongs:
   a) jellyfish
   b) mango
   c) scorpion

d) earthworm

e) tapeworm

f) whale

g) mushroom

h) blue-green algae

i) toad

j) bacteria

6. a) What do scientists look for when classifying organisms?

   b) What determines if an animal is called a vertebrate or an invertebrate?

   c) Choose one invertebrate phylum and one vertebrate class. Describe the characteristics of the group and give two clear examples.

7. a) Which group of animals has wings and six legs?

   b) State the class for each of the following animals: snake, toad, termite.

8. A reptile and an amphibian both lay eggs. Explain why they are separated into two different classes.

9. a) How do flatworms, annelid worms and roundworms differ from each other?

   b) How do mosses differ from conifers?

   c) How do fungi differ from plants?

10. This table shows some of the characteristics of animals. Copy it out and fill in the equivalent characteristics of plants.

Animals	Plants
a) Move whole of the body from one place to another	
b) Grow up to a maximum size in life	
c) Have a variety of colours	
d) Respond to stimuli quickly	
e) Show complex behaviour patterns	
f) Feed on other organisms	
g) Give out carbon dioxide all the time	

Copy this table into your exercise book (or your teacher may give you a photocopy). Draw a pencil line through each of the words in the list below as you find it.

Words go up and down in both directions

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

Word search: In this table you will find 16 words linked to classification.

They are:

monera	fungi	plantae	animalia
species	taxonomy	dicot	fern
fish	eukaryotic	prokaryotic	phylum
genus	order	kingdom	key