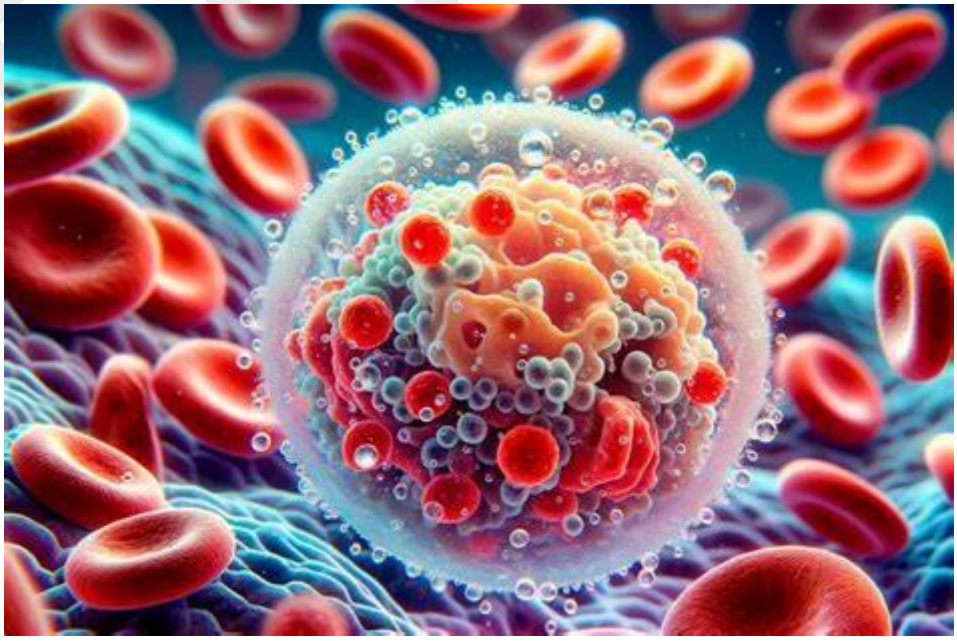
# Cambridge OL

# Biology

CODE: (5090)

# Chapter 02

# Classification



# Classification systems

**Key definitions**

A **species** is a group of organisms that can reproduce to produce fertile offspring.

The **binomial system** of naming organisms is an internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species.

There are millions of different organisms living on the Earth. Biologists sort them into a meaningful order, they **classify** them.

Biologists seek a natural classification system for organisms, focusing on shared features. This approach is often difficult, as animals like birds share common features like wings, beaks, and feathers. However, biologists constantly change their ideas, suggesting new groupings and abandoning old ones, as they find it more meaningful to group organisms based on shared characteristics.

## Species

Members of a species also often look very similar to each other in appearance, Common mynas, eagles and parrots are three different species of bird. Apart from small **variations**, members of a species are almost identical in their anatomy, physiology and behaviour.

Closely related species are grouped into a **genus** (plural: **genera**). For example, there are 45 species of bronzeback snake, all in the same **genus** Dendrelaphis.

## Binomial nomenclature

People living in the Indian subcontinent are familiar with the appearance of a robin. The male is mainly black, with some red–brown bottom feathers (although some more northern **populations** are more brown than black). Males also have a white flash across their shoulder. The female has completely brown upper feathers and grey–brown underparts. Its scientific name is Copsychus fulicatus and the adult is about 17 cm long (see Figure 2.1).

▲ **Figure 2.1** Indian robin, *Copsychus fulicatus* ♂

▲ **Figure 2.2** British robin, *Erithacus rubecula* ♂

## Dichotomous keys

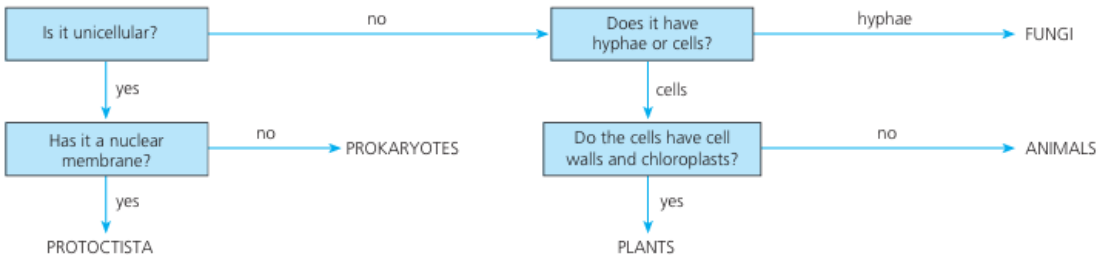
We use **dichotomous keys** to identify unfamiliar organisms. Keys simplify the process of identification. Each key is made up of pairs of contrasting features (dichotomous means two branches), starting with quite general characteristics and moving on to more specific ones.

Figure 2.3 shows an example of a dichotomous key that could be used to place an unknown **vertebrate** in the correct class.

VERTEBRATE CLASSES

| | | |
|---|---|---|
| 1 | Cold-blooded | 2 |
| | Warm-blooded | 4 |
| 2 | Has fins but no limbs | **Fish** |
| | Has four limbs | 3 |
| 3 | Has no scales on body | **Amphibian** |
| | Has scales | **Reptile** |
| 4 | Has feathers | **Bird** |
| | Has fur | **Mammal** |

▲ **Figure 2.3** A dichotomous key for vertebrate classes




▲ **Figure 2.5** Identification plan

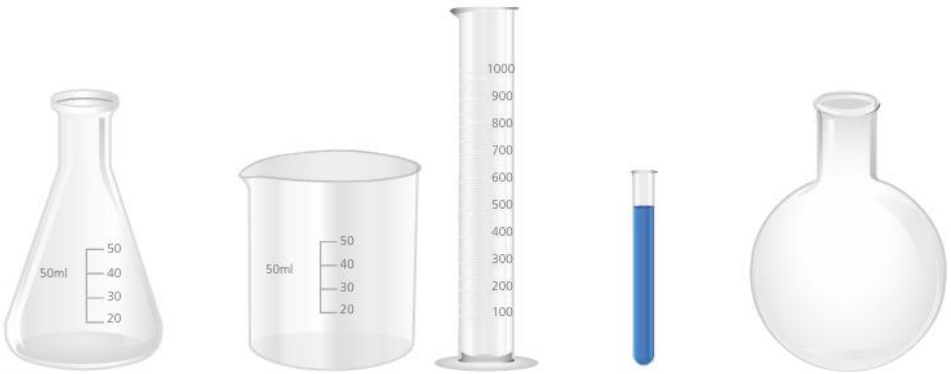
Figure 2.4 is a key for identifying some of the possible invertebrates to be found in a compost heap. Of course, you do not need a key to identify these familiar animals, but it does show you how a key can be constructed.

First you need to study the items, to work out what some of them have in common and what makes them different from others.

INHABITANTS OF A COMPOST HEAP

| | | |
|---|---|---|
| 1 | Has legs | 2 |
| | No legs | 5 |
| 2 | More than six legs | 3 |
| | Six legs | 4 |
| 3 | Short, flattened grey body | **Woodlouse** |
| | Long brown/yellow body | **Centipede** |
| 4 | Pincers on last segment | **Earwig** |
| | Hard wing covers | **Beetle** |
| 5 | Body segmented | **Earthworm** |
| | Body not segmented | 6 |
| 6 | Has a shell | **Snail** |
| | No shell | **Slug** |

▲ **Figure 2.4** A dichotomous key for some invertebrates in a compost heap




▲ **Figure 2.6** Items of laboratory glassware

The first question should be based on a feature that will split the group into two. The question is going to give a 'yes' or 'no' answer. For each of the two subgroups formed, a further question based on the features of some of that sub-group should then be written. Figure 2.7 shows one possible solution.

## Features of organisms

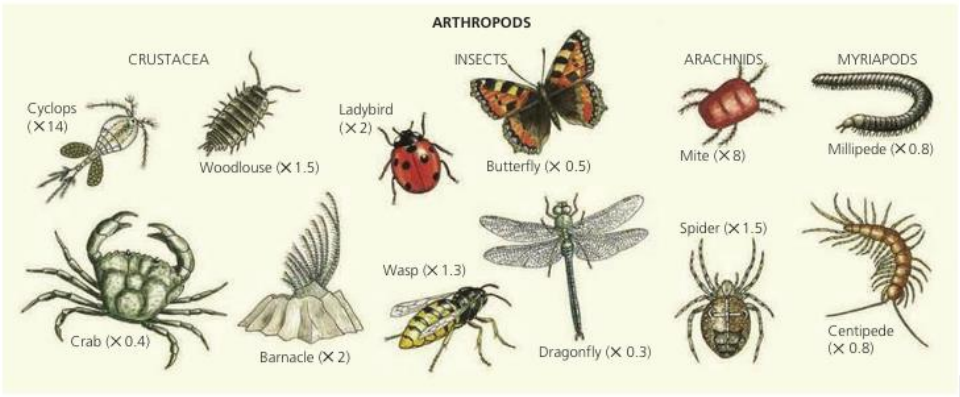
All living organisms have certain features in common, including the presence of cytoplasm and cell membranes, and DNA as genetic material. A **kingdom** is a category of living organisms.

| | | |
|---|---|---|
| 1 | Has it got a pouring spout? | |
| | Yes | 2 |
| | No | 3 |
| 2 | Has it got a broad base? | |
| | Yes | **Beaker** |
| | No | **Measuring cylinder** |
| 3 | Has it got straight sides for the whole of its length? | |
| | Yes | **Boiling tube** |
| | No | 4 |
| 4 | Has it got sloping sides? | |
| | Yes | **Conical flask** |
| | No | **Round-bottomed flask** |

▲ **Figure 2.7** Dichotomous key for identifying laboratory glassware

## The animal kingdom

Animals are multicellular organisms whose cells have no cell walls or chloroplasts. Most animals ingest solid food and digest it internally.




▲ **Figure 2.13** The animal kingdom; examples of arthropods – one of the invertebrate groups (phyla)

(Only two groups out of 23 are listed here.) Each group is called a phylum (plural = phyla).

* **Arthropods**
CLASS
Crustacea (crabs, shrimps, water fleas)
Insects
Arachnids (spiders and mites)
Myriapods (centipedes and millipedes)

**Vertebrates**
CLASS
Fish
Amphibia (frogs, toads, newts)
Reptiles (lizards, snakes, turtles)
Birds
Mammals

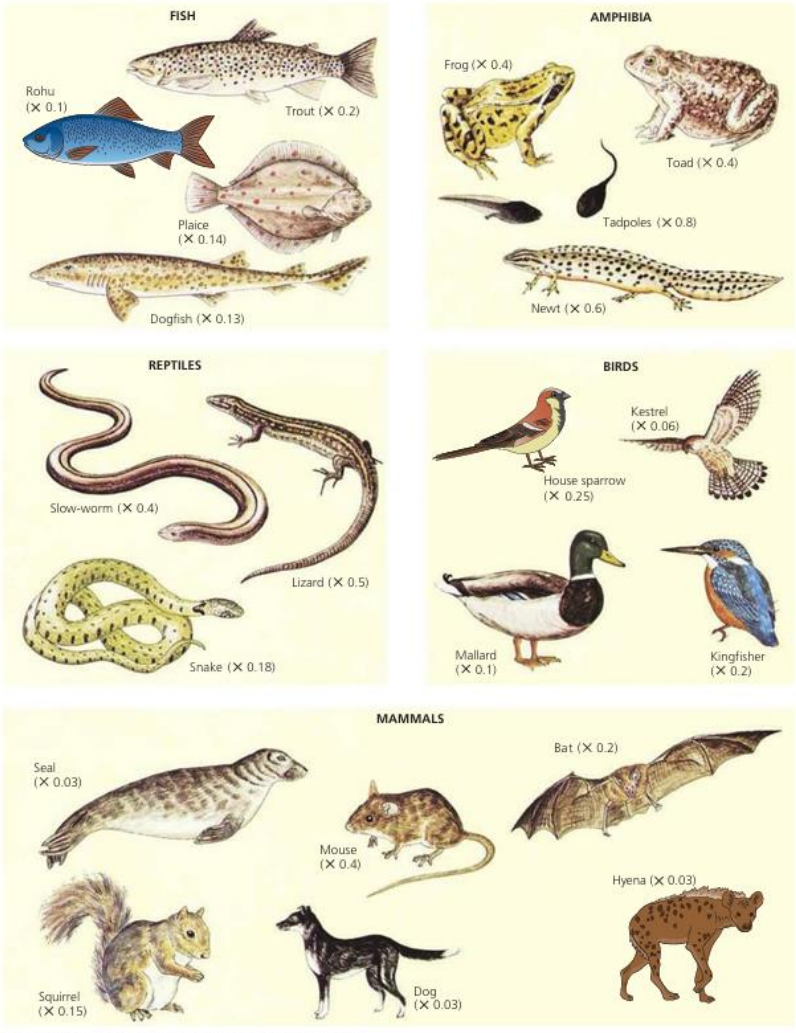
*All the organisms that do not have a vertebral column are often called invertebrates. Invertebrates are not a natural group, but the term is convenient to use.

## Arthropods

The arthropods include the crustacea, insects, centipedes and spiders (see Figure 2.13). The name arthropod means 'jointed limbs', and this is a feature common to them all. They also have a hard, firm, external skeleton, called a **cuticle**, which encloses their bodies.

## Crustacea

Some of these crustacea are shown in Figure 2.13. Like all arthropods, crustacea have an exoskeleton (a rigid external skeleton) and jointed limbs. Compound eyes are made up of tens or hundreds of separate **lenses** with light-sensitive cells underneath.

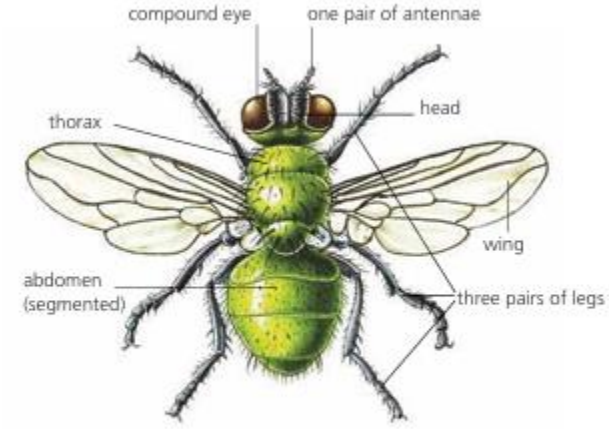



▲ **Figure 2.14** The animal kingdom; the vertebrate classes

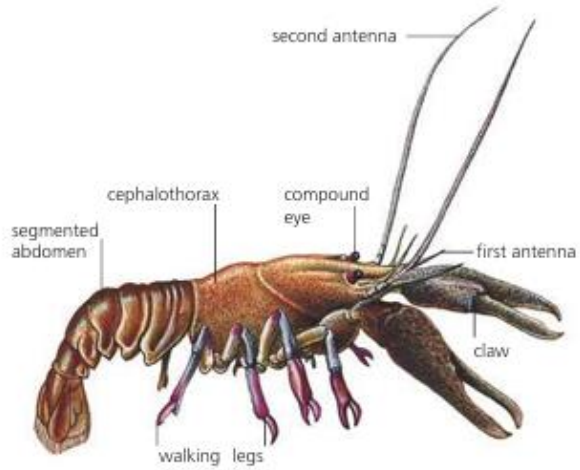
Most crustacea have a pair of jointed limbs on each segment of the body, but those on the head segments are modified to form antennae or specialised mouth parts for feeding (see Figure 2.15).

## Insects

Insects are a large class of arthropods, including wasps, butterflies, mosquitoes, houseflies, earwigs, greenflies, and beetles. They have segmented bodies with a firm exoskeleton, jointed legs, compound eyes, and wings.



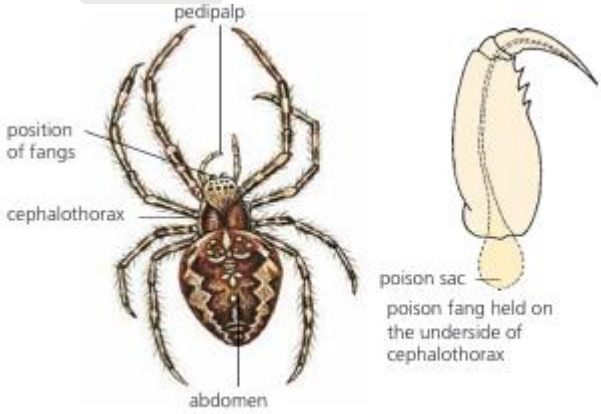

▲ **Figure 2.16** External features of an insect (greenbottle ×5). Flies, midges and mosquitoes have only one pair of wings




▲ **Figure 2.15** External features of a crustacean (lobster ×0.2)

## Arachnids

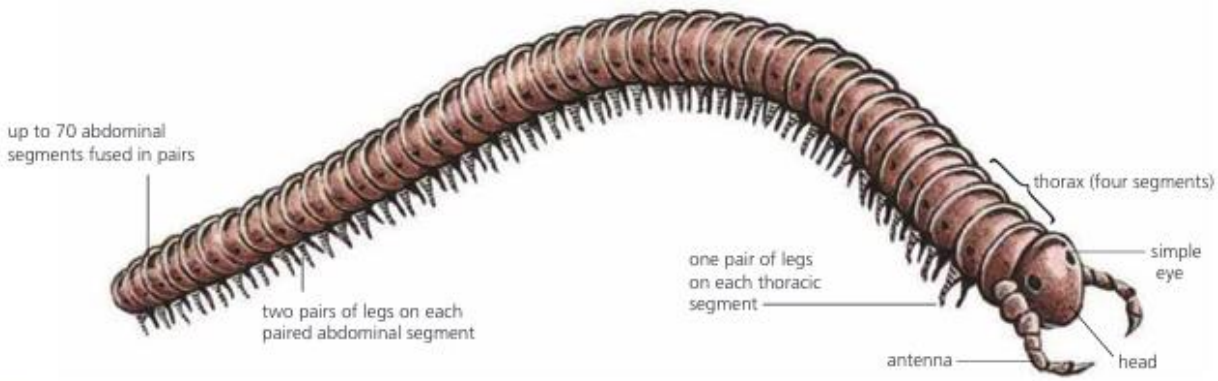
These are spiders, scorpions, mites and ticks. Their bodies are divided into two regions, a combined head and thorax region, called the cephalothorax, and the abdomen (see Figure 2.17). They have four pairs of limbs on their cephalothorax. In addition, there are two pairs of pedipalps.




▲ **Figure 2.17** External features of an arachnid (×2.5)

## Myriapods

As the myriapod grows, extra segments are formed. The myriapods have one pair of antennae and simple eyes. Centipedes are **carnivores**, feeding on other animals, but millipedes are **herbivores**, feeding on plant material.




▲ **Figure 2.18** External features of a myriapod (×2.5)

▼ **Table 2.1** Key features of the four classes of arthropods

| Insects | Arachnids | Crustacea | Myriapods |
|---|---|---|---|
| e.g. dragonfly, wasp | e.g. spider, mite | e.g. crab, woodlouse | e.g. centipede, millipede |
| • three pairs of legs | • four pairs of legs | • five or more pairs of limbs | • 10 or more pairs of legs (usually one pair per segment) |
| • body divided into head, thorax and abdomen | • body divided into cephalothorax and abdomen | • body divided into cephalothorax (combined head and thorax) and abdomen | • body not obviously divided into thorax and abdomen |
| • one pair of antennae | • no antennae | • two pairs of antennae | • one pair of antennae |
| • one pair of compound eyes | • several pairs of simple eyes | • one pair of compound eyes | • simple eyes |
| • usually have two pairs of wings | • pair of pedipalps adapted for biting and poisoning prey | • exoskeleton often forms a hard covering over most of the body | |

## Vertebrates

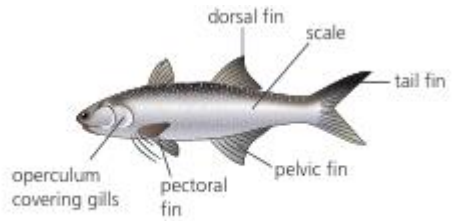
Vertebrates are animals with a vertebral column, also known as the spinal column, consisting of cylindrical bones. Each vertebra has an arch protecting the spinal cord, which forms the brain. The skull contains a pair of jaws with teeth. Vertebrates are classified into five classes: fish, amphibia, reptiles, birds, and mammals.

## Body temperature

Fish, amphibia, and reptiles are often referred to as 'cold-blooded', but they actually have a variable body temperature that depends on their surroundings. Warm-blooded animals have a higher body temperature but maintain it mainly through internal regulatory mechanisms. This allows them to maintain activity without being affected by the surrounding temperature, which can be advantageous for predators.

## Fish

Fish reproduce sexually but **fertilisation** usually takes place externally; the female lays eggs and the male sheds sperms on them after they have been laid.

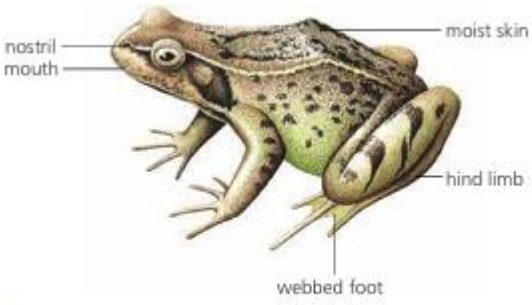



▲ **Figure 2.19** Rawas (*Eleutheronema* ×0.1)

## Amphibia

Amphibia, including frogs, toads, and newts, are cold-blooded vertebrates with four limbs and no scales. They have a 'double life', spending part of their lives in water and part on land, returning only for egg-laying.

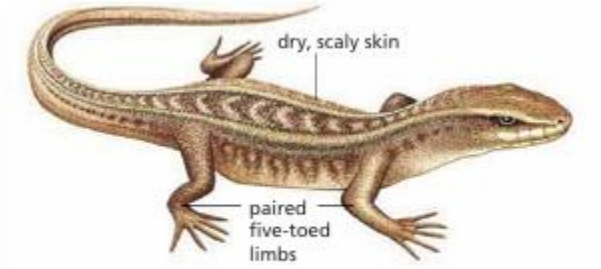
Amphibia have moist skins with a good supply of **capillaries**, which can exchange oxygen and carbon dioxide with the air or water. They also have lungs that can be inflated by a kind of swallowing action. They do not have a **diaphragm** or ribs.




▲ **Figure 2.20** *Rana* (×0.75)

## Reptiles

Reptiles are land-living vertebrates with dry skins and scaled outer layers, reducing water loss. They breed in damp habitats and lack water for breeding. They regulate temperature by lying in the sun, allowing them to chase prey. Reptiles include lizards, snakes, turtles, tortoises, and crocodiles.



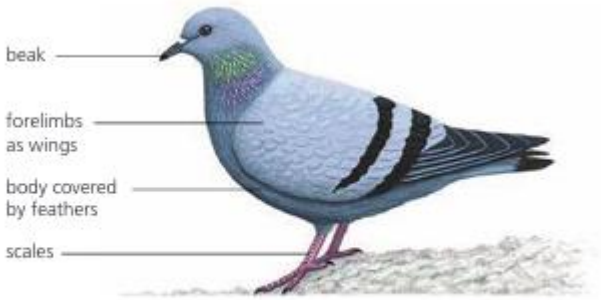

▲ **Figure 2.22** *Lacerta* (×1.5)

▲ **Figure 2.21** Frogs pairing. The male clings to the female's back and releases his sperm as she lays the eggs

## Birds

Birds are warm-blooded vertebrates. The vertebral column in the neck is flexible but the rest of the vertebrae are merged to form a rigid structure. This is probably an adaptation to flight, as the powerful wing muscles need a rigid frame to work against.

Birds have four limbs, but the forelimbs are modified to form wings. The feet have four toes with claws, which help the bird to perch, scratch for **seeds** or capture prey, according to the species




▲ **Figure 2.23** The main features of a pigeon (×0.14)

## Mammals

Humans are mammals. All mammals give birth to fully formed young instead of laying eggs. The eggs are fertilised internally and go through a period of development in the **uterus**.

Early young animals, such as cats and sheep and goats, suck milk from their mothers' teats, which contains essential nutrients for their first few weeks or months. As they grow older, they feed on the same food as their parents, with carnivores providing food until they can self-suffer.

▲ **Figure 2.24** Mammalian features. The furry coat, the external ear flaps (pinnae) and the facial whiskers are visible mammalian features in this gerbil

▼ **Table 2.2** Key features of the five classes of vertebrates

| Vertebrate class | Fish | Amphibia | Reptiles | Birds | Mammals |
|---|---|---|---|---|---|
| Examples | trout, rohu, sharks | frog, toad, newt | lizard, snake | sparrow, pigeon | mouse, striped hyena |
| Body covering | scales | moist skin | dry skin with scales | feathers, with scales on legs | fur |
| Movement | fins (also used for balance) | four limbs, back feet are often webbed to make swimming more efficient | four legs (apart from snakes) | two wings and two legs | four limbs |
| Reproduction | produce jelly-covered eggs in water | produce jelly-covered eggs in water | produce eggs with a rubbery, water-proof shell; laid on land | produce eggs with a hard shell; laid on land | produce live young |
| **Sense organs** | eyes; no ears; lateral line along body for detecting vibrations in water | eyes; ears | eyes; ears | eyes; ears | eyes; ears with a pinna (external flap) |
| Other details | cold-blooded; gills for breathing | cold-blooded; lungs and skin for breathing | cold-blooded; lungs for breathing | warm blooded; lungs for breathing; beak | warm blooded; lungs for breathing; females have mammary glands to produce milk to feed young; four types of teeth |

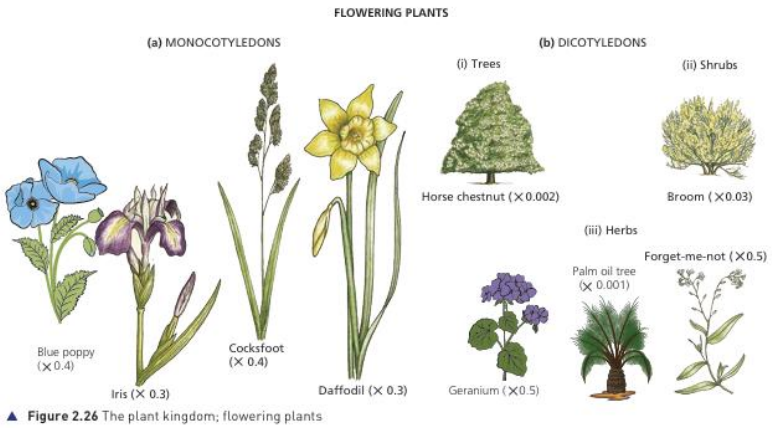
## The five-kingdom scheme

Many biologists now favour the five-kingdom scheme. This is a scheme that consists of Animal, Plant, **Fungus**, Prokaryote and **Protoctist**.

**Viruses** are not included in any kingdom – they are not considered to be living organisms because they do not have cell membranes (made of protein and lipid), cytoplasm and ribosomes, and do not demonstrate the characteristics of living things: they do not feed, respire, excrete or grow.

## The plant kingdom

Plants are made up of many cells – they are multicellular. Plant cells have an outside wall made of cellulose. Many of the cells in plant leaves and stems contain chloroplasts with photosynthetic pigments (e.g. chlorophyll). Plants make their food by photosynthesis.




▲ **Figure 2.26** The plant kingdom; flowering plants

## Ferns

The leaves of ferns vary from one species to another (see Figures 2.27 and 2.28), but they are all several cells thick. Most of them have an upper and lower epidermis, a layer of palisade cells and a **spongy mesophyll**, like the leaves of a flowering plant.

▲ **Figure 2.27** Young fern leaves. Ferns do not form buds like those of the flowering plants. The midrib and leaflets of the young leaf are tightly coiled and unwind as it grows

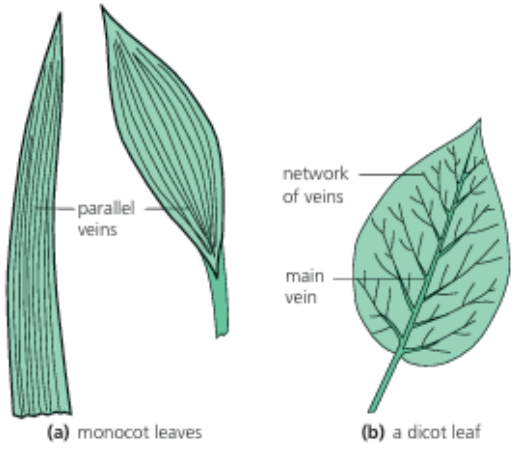

▲ **Figure 2.28** The plant kingdom; ferns – one group of plants that does not bear seeds

Ferns produce **gametes** but no seeds. The **zygote** gives rise to the fern plant, which then produces single-celled spores from many **sporangia** (spore capsules) on its leaves. The sporangia are formed on the lower side of the leaf, but their position depends on the species of fern.

## Flowering plants

Flowering plants reproduce by seeds that are formed in flowers. The seeds are enclosed in an **ovary**. The general structure of flowering plants is described in Chapter 7. Examples are shown in Figure 2.26 on page 34. Flowering plants are divided into two subclasses: **monocotyledons** and **dicotyledons**. Monocotyledons (monocots for short) are flowering plants that have only one cotyledon in their seeds.

▲ **Figure 2.29** Polypody fern. Each brown patch on the underside of the leaf is made up of many sporangia




▲ **Figure 2.30** Leaf types in flowering plants

## The Fungi kingdom

Most fungi are made up of thread-like hyphae (see Figure 2.31), rather than cells, and there are many nuclei scattered throughout the cytoplasm in their hyphae (see Figure 2.32).

The fungi include organisms such as mushrooms, toadstools, puffballs and the bracket fungi that grow on tree trunks (Figure 2.33). There are also the less obvious, but very important, mould fungi, which grow on stale bread, cheese, **fruit** or other food.

Fungal parasites live in other organisms, particularly plants, where they cause **diseases** that can affect crop plants, such as the mildew shown in Figure 2.34.

▲ **Figure 2.33** A parasitic fungus. The 'brackets' are the reproductive structures. The mycelium in the trunk will eventually kill the tree

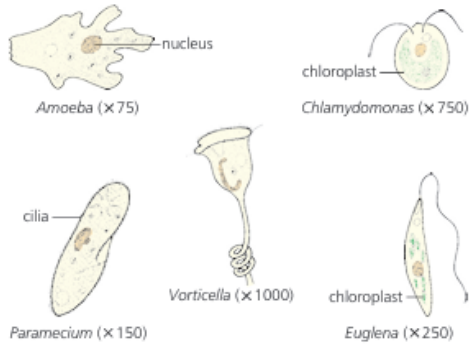
▲ **Figure 2.34** Mildew on wheat. Most of the hyphae are inside the leaves, digesting the cells, but some grow out and produce the powdery spores seen here

## The Prokaryote kingdom

These are the bacteria and the blue-green algae. They consist of single cells but are different from other single-celled organisms because their chromosomes are not organised into a nucleus.

## The Protoctist kingdom

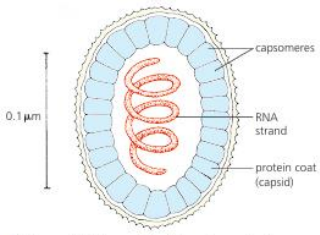
Unicellular organisms, such as Protoctista and Amoeba, are single-celled organisms with chromosomes enclosed in a nuclear membrane. Some have chloroplasts and feed through photosynthesis. Amoeba and Paramecium are animal-like in their feeding, while Vorticella feeds by creating a current of water with cilia.




▲ **Figure 2.35** Protoctista. *Chlamydomonas* and *Euglena* have chloroplasts and can photosynthesise. The others are protozoa and ingest (take in) solid food

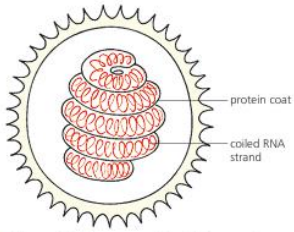
## Viruses

Viruses have a central RNA or DNA core surrounded by a protein coat, lacking a nucleus, cytoplasm, cell organelles, or cell membrane. They reproduce only within living organisms, using materials provided by the host cell. A generalized virus particle has a coiled single RNA strand with a capsid protein coat.




▲ **Figure 2.36** Generalised structure of a virus

One example of a virus is the influenza virus (Figure 2.37).




▲ **Figure 2.37** Structure of the influenza virus

# Revision questions

1) Fig. 1 is a branching key used to identify different species of bacteria.

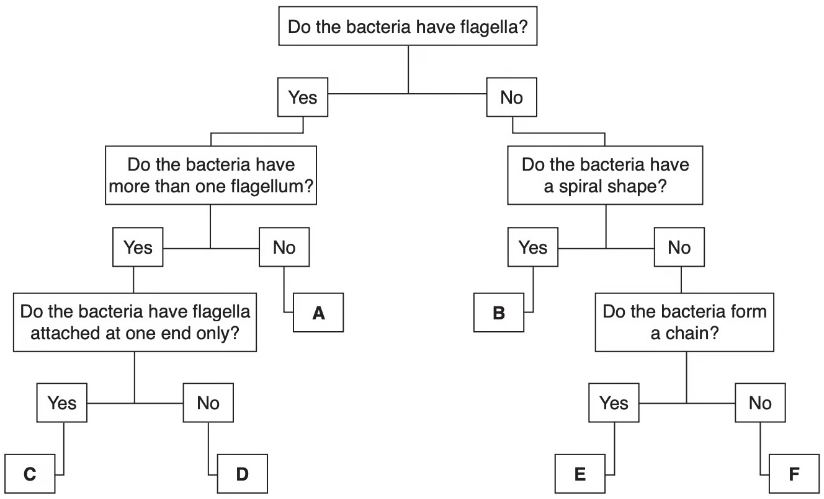



**Fig. 1**

Fig. 2 shows six different species of bacteria.

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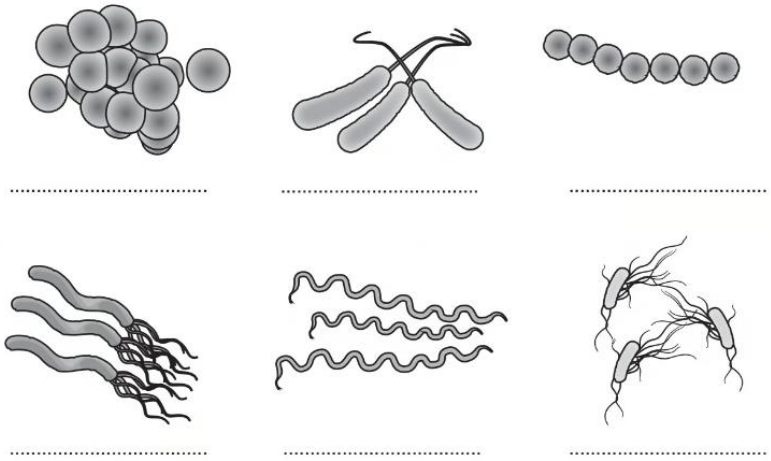

**Fig. 2**

(i) Use the key to identify the six different species of bacteria.

(ii) State the name of the kingdom that bacteria belong to.

2)

The scientific name for humans is *Homo sapiens*.

State the level of classification referred to by each part of the scientific name:

*Homo*.....

*Sapiens*.....

3)

The animal in Fig. 1 is a chimpanzee.

**Fig. 1**

(i) The chimpanzee is a vertebrate.

State the main group of vertebrates to which the chimpanzee belongs.

(ii) State **two** features, visible in Fig. 1, which suggest that it belongs to this group of vertebrates.

b)

The binomial system of naming species gives chimpanzees the name *Pan troglodytes*.

Describe what is meant by the binomial system of naming species.

c)

Chimpanzees are classified taxonomically as a single species, *Pan troglodytes*.

Define what is meant by the term ***species***.

4)

The organisms shown in Fig. 1 are a group of invertebrates called arachnids.

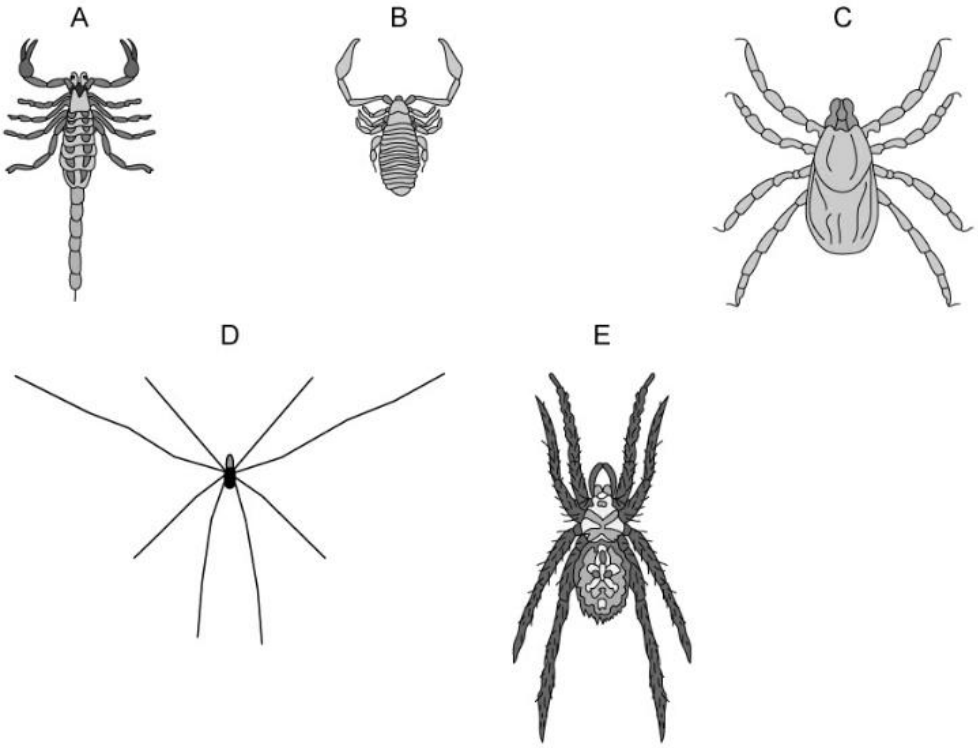


**Fig. 1**

Describe the common features of arachnids visible in Fig. 1.

b)

Use the key shown below to identify the arachnids shown in Fig. 1.

| | | | |
|---|---|---|---|
| 1 | a | Has a tail structure | *Scorpiones* |
| | b | Does not have a tail structure | go to 2 |
| 2 | a | Has large pair of front pincers | *Pseudoscorpiones* |
| | b | Does not have large front pincers | go to 3 |
| 3 | a | Legs are at least three times as long as the body | *Pholcidae* |
| | b | Legs are similar or smaller in length than the body | go to 4 |
| 4 | a | Legs have visible spines/hairs | *Lycosidae* |
| | b | Legs do not have visible spines/hair | *Ixodida* |

c) Dichotomous keys can be used to help classify organisms.

Explain the purpose of classification systems.

5) a)

Dichotomous keys can be used to identify organisms based on a series of questions about their features.

Fig. 1 shows a group of leaves.

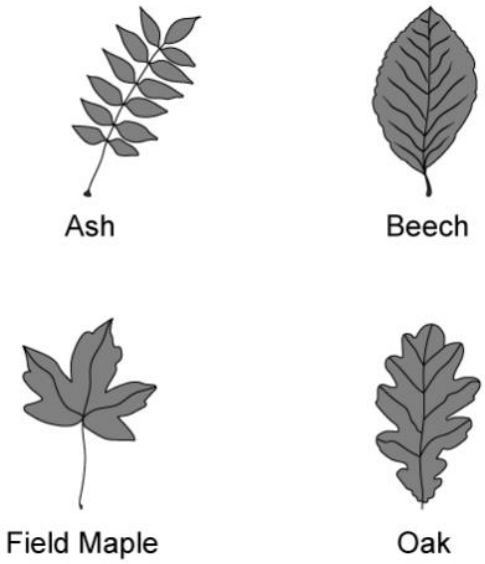


**Fig. 1**

Suggest a dichotomous key for the leaves shown in Fig. 1 by completing Table 1. An example has been done for you.

**Table 1**

| | | statement | answer / instruction |
|---|---|---|---|
| 1 | a | leaf is oval shaped | beech |
| | b | leaf is not oval shaped | go to 2 |
| 2 | a | | |
| | b | | |
| 3 | a | | |
| | b | | |

b) Fig. 2 shows a different type of dichotomous key where invertebrates are classified.

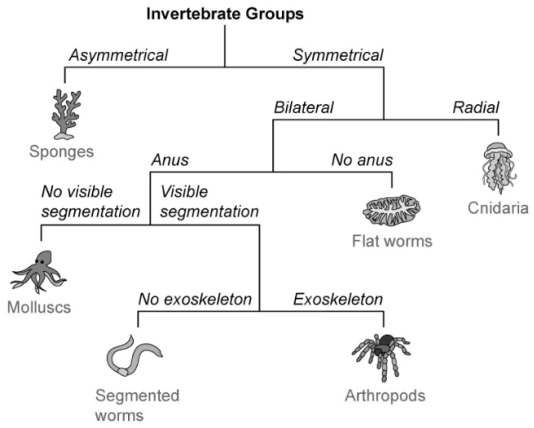


**Fig. 2**

Complete the dichotomous key to show the classification of arthropods into their four sub groups.

c) Fig. 3 shows a range of different plants.

(i) Give the type of plant, (monocotyledons, dicotyledons or ferns) for each plant labelled **A**-**F**.

[3]

(ii) Describe the evidence shown in Fig. 3 that informed your answer for plant **F**.

[1]

6) a) Table 1 shows the names of three groups of arthropods and some of their characteristics. Place ticks (✓) in the boxes to show the characteristics present in each group.

**Table 1**

| characteristic | arthropod group | | |
|---|---|---|---|
| | arachnids | crustaceans | myriapods |
| four pairs of legs | | | |
| one pair of antennae | | | |
| body divided into two main parts | | | |

b) Fig. 1 shows the apparatus used by some students during an investigation.The apparatus is drawn as seen from above.

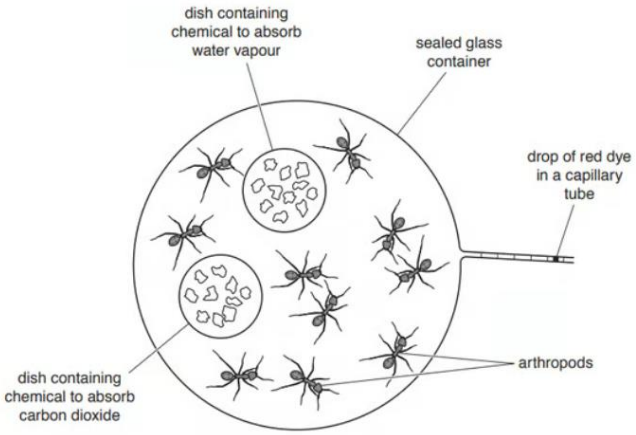


**Fig. 1**

Some arthropods were placed in the container.

A drop of red dye was inserted into the capillary tube.

The drop of red dye in the capillary tube gradually moved towards the arthropods.

(i) Explain why the drop of red dye moved towards the arthropods.

The investigation shown in Fig. 1 was repeated at different temperatures.

Fig. 2 shows the results.

(ii) State the trend shown in Fig. 2.

(iii) Calculate the percentage increase in the rate of dye movement between 10°C and 20°C.

Show your working.

(i) State the group of arthropods the student used in Fig. 1.

(ii) Describe the features visible in Fig. 1 that identify this group.

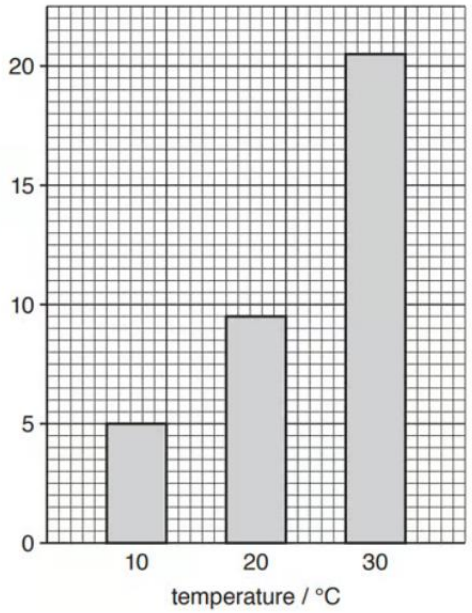


**Fig. 2**

7) a)

A scientist discovered a new organism and observed some cells from the organism. Table 1 below shows some of the features observed during examination.

**Table 1**

| feature | observations |
|---|---|
| cell type | multicellular |
| cell wall | chitin |
| food source | saprophytic or parasitic |
| nucleus | present |
| other organelles | mitochondria, ribosomes |

Suggest which Kingdom the organism belongs to using the observations recorded by the scientist.

b) The scientist used DNA sequencing to further study the cells.

Explain why the scientist used DNA sequencing.

c) All animals share some similarities and differences with prokaryotes.

Compare the main features of animals and prokaryotes.

8) a) Flowering plants can be divided into two groups.

(i) State the two groups of flowering plants.

(ii) Explain how to distinguish between the two groups.

b) A student found the plant shown in Fig. 1 growing in the school grounds.

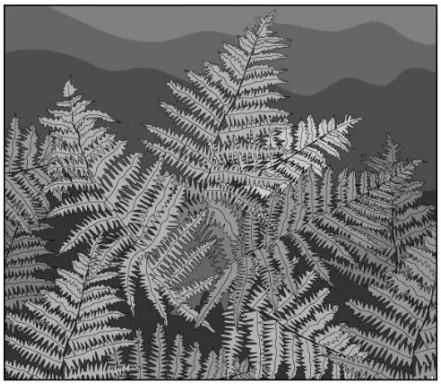

**Fig. 1**

Explain what type of plant this would be classified as.

9) a) Scientists classify organisms into groups.

State **one** feature that is used to identify vertebrates.

b) Vertebrates are classified into five groups.Fig. 1 shows three vertebrates found in Australia.

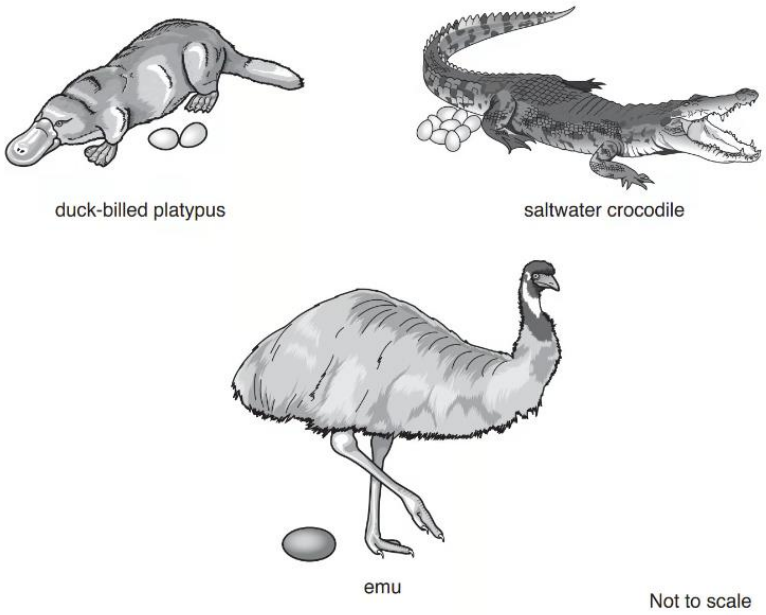


**Fig. 1**

The emu, the saltwater crocodile and the duck-billed platypus each belong to a different vertebrate group.

All three animals lay eggs that develop and hatch on land.

(i) State the name of the vertebrate group to which emus belong and give **one** feature of this group that is visible in Fig. 1.

[2]

(ii) State the name of the vertebrate group to which crocodiles belong and give **one** feature of this group that is visible in Fig. 1.

[2]

(iii) The duck-billed platypus is classified as a mammal.

Give evidence from Fig. 1 **for and against** classifying the duck-billed platypus as a mammal.

[3]