Imagine how difficult it would be to identify one of the millions of living things in the world if people couldn’t agree on one system for classifying (or grouping) them. Fortunately, there is a worldwide classification system that most scientists do agree on. It groups living things according to the structural features they have in common. Structural features include skull shape, teeth, number of legs, as well as the structure of the cells that make them up.

**Sorting things out**

Swedish naturalist Carl von Linné (1707–1778) — also known as Linnaeus — was the first person to develop a proper system for classifying living things. It is known as the Linnaean system.

Using the Linnaean system, only two names are needed to identify an organism — a genus name and a species name (see the diagram below). This two-part name, called a scientific name, is always written in Latin. The genus name starts with a capital letter. For example, *Felis catus* is the scientific name of the organism with the common name (or everyday name) of house cat. *Lycopersicon lycopersicum* is the scientific name for a tomato plant.

**Taxonomists** are scientists who decide how organisms are classified. They divide living things into smaller and smaller groups based on their common features or characteristics. The smaller the group, the more features its members have in common. For example, members of the same family have more features in common than members of the same class. Members of a species have more in common than members of a genus.

When members of the same species mate, they are able to produce fertile young. This is possible even though the individuals are not identical. For example, not all domestic cats (*Felis catus*) have the same colour, type of fur or ear shape. But all cats can mate with each other to produce fertile young. In the same way, not all tomato plants look the same size and shape but they are still one species. They can reproduce to give more tomato plants, which can then reproduce and give more tomato plants and so on.

If members of different species mate, their offspring will not be fertile.

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How living things are classified, using the Linnaean system

<table>
<thead>
<tr>
<th>Animalia</th>
<th>Kingdom</th>
<th>Plantae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chordata</td>
<td>phylum* or division**</td>
<td>Magnoliophyta</td>
</tr>
<tr>
<td>Mammalia</td>
<td>class</td>
<td>Magnoliopsida</td>
</tr>
<tr>
<td>Carnivora</td>
<td>order</td>
<td>Solanales</td>
</tr>
<tr>
<td>Felidae</td>
<td>family</td>
<td>Solanaceae</td>
</tr>
<tr>
<td>Felis</td>
<td>genus</td>
<td>Lycopersicon</td>
</tr>
<tr>
<td>catus</td>
<td>species</td>
<td>lycopersicum</td>
</tr>
</tbody>
</table>

*Phylum* for Kingdom Animalia  
**Division** for Kingdom Plantae

The five kingdoms into which organisms are classified

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Science Alive for VELS Level 5
The five kingdoms

Most scientists today accept that there are five different kingdoms: Animalia, Plantae, Monera, Protocista and Fungi.

Animalia includes worms, snails, fish, frogs, insects, reptiles, birds and mammals (such as dogs, camels and humans). They are complex organisms made up of many, often millions, of cells. They obtain food by eating or absorbing other living (alive or dead) things.

Plantae includes mosses, grasses, flowering plants, shrubs and trees. They are made up of many cells that contain chlorophyll. Chlorophyll allows plants to use the energy of sunlight to make their own food from carbon dioxide and water. Oxygen is released as a waste product. This food-making process is called photosynthesis.

Fungi includes mushrooms, toadstools, moulds, mildew and yeasts. They are usually made up of many cells, but some have only one. Unlike plants, they have no true leaves, flowers, stems — or chlorophyll. They obtain their food by growing on other organisms (alive or dead).

Protocista includes green algae (from single-celled diatoms to multi-celled organisms such as kelp) and the single-celled amoeba. Although they may have some of the features of plants or animals, they cannot be classified as either of these. They live mostly in water.

Monera includes bacteria and cyanobacteria. They are the simplest organisms on Earth, being made up of one cell. Most get their food from other organisms such as dead animals and plants. Some bacteria cause disease; other bacteria are used to make foods such as yoghurt.
How many different species of animal can you think of? Not even scientists know how many there are on Earth. Over one million animal species have been classified so far, but hundreds of new species are being discovered every year. The task of classifying newly discovered animals begins with carefully observing their body characteristics.

There is a huge variety of animals on Earth. They range from the massive blue whale (about 24 m long and 100,000 kg in weight) down to creatures that are so small that we need a microscope to see them. Animals hop, swim, fly, walk and slide through their environments. Some live all their lives in water; others live in the soil, on icy slopes or in treetops. Each type of animal has characteristics that best suit the environment in which it lives.

**Vertebrates**

There are many ways in which the massive animal kingdom could be broken down into smaller groups of animals that are more alike. Most scientists today start grouping them by whether or not they have a backbone. Animals with backbones are called **vertebrates**. The backbone is part of the skeleton inside the body of the animal. The scientific name for the vertebrates is Phylum Chordata.

**Invertebrates**

Animals without a backbone are called **invertebrates**. These animals may have an external skeleton (called an **exoskeleton**), or no skeleton at all. An exoskeleton may be a shell or a hard, jointed covering that encloses the body. A growing animal with an exoskeleton sheds it from time to time. It is then replaced by a larger exoskeleton. This shedding is necessary because an exoskeleton does not grow like the bones in our skeleton do.

The largest animal on Earth, the blue whale, feeds on some of the smallest animals on Earth. Every day in the summer feeding season, an average-sized blue whale eats up to 4 tonnes of tiny animals like those shown below.
Three-quarters of all animal species have an exoskeleton. Most of these are **arthropods** (such as insects and spiders). Animals with exoskeletons are usually not as flexible as those with skeletons inside the body. Exoskeletons prevent an animal from bending and twisting easily because the muscles are attached to the inside of the hard skeleton. The muscles of animals with an internal skeleton are attached outside the skeleton and can pull on parts of the skeleton to move it in many directions.

Some animals with no skeleton at all, such as worms and jellyfish, have strong muscles. Their muscles contract (get shorter) and stretch to allow their bodies to move through their environment.

**REMEMBER**
1. Describe the difference between vertebrates and invertebrates.
2. What is an exoskeleton?
3. What is the largest group of animals with an exoskeleton?

**THINK**
4. Which group of animals is the more common — vertebrates or invertebrates?
5. Is a snail a vertebrate or an invertebrate? Give a reason for your answer.
6. Worms have muscles around and along their bodies. These allow them to become long and thin one moment and short and fat the next. How might this help them move through the earth?
7. The system most scientists use for classifying animals that can be seen without a microscope starts by dividing them into those with and without a backbone. Suggest at least one other way to divide them into two groups.
8. Select a characteristic for the following group of animals to divide it into:
   (a) two groups
   (b) three groups.
   dolphin, slug, beetle, horse, jellyfish, dog, spider, ant

**SKILLBUILDER**
9. Study the dichotomous key opposite.
   (a) To which group does each of the animals below belong?
      • One with a backbone, a changing body temperature and that does not use air tubes or lungs
      • One with no backbone, legs or covering shell and that has tentacles with stinging cells.
   (b) Work through the key backwards to list as many characteristics as you can for:
      • birds
      • molluscs
      • reptiles.
We need plants to live. They provide the oxygen we breathe, the food we eat and the food eaten by animals we eat. They also provide medicines, and raw materials such as timber and cloth fibres. Scientists think there may be about 350,000 species of plants, but no-one is sure. Plants are classified on the basis of features such as the presence of roots, stems, leaves, seeds and flowers.

Like most members of the animal kingdom, plants are complex multicellular organisms. Unlike animals, they:

- have structures such as roots, stems and leaves
- have thick cell walls
- make their own food through a process called photosynthesis
- are not free to move from place to place.

Classifying plants

One of the main ways plants can be grouped is by whether or not they have transport tissue. Known as vascular tissue, this transport tissue consists of two sets of tubes. One set, made of phloem cells, transports food from the leaves to the rest of the plant. The other set, made of xylem cells, transports water and minerals from the soil to the rest of the plant.

Plants with vascular tissue are called tracheophytes. They have roots, stems and leaves. They include flowering plants, conifers and ferns. Plants that do not have vascular tissue are called bryophytes. They are usually very small plants. Bryophytes include mosses and liverworts.
### Stem and roots

<table>
<thead>
<tr>
<th>Yes</th>
<th>Yes — mostly fine and needle-shaped</th>
<th>No</th>
<th>Yes — form on scales of cones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes — fine and needle-shaped</td>
<td>No</td>
<td>Yes — reproduce from spores on leaves. These are released from brown spore cases that form on the underside of leaves.</td>
</tr>
<tr>
<td>No stem. ‘Roots’ are more like fine hairs.</td>
<td>Yes, but simple structure — tiny and dainty</td>
<td>No</td>
<td>No — reproduce from spores</td>
</tr>
<tr>
<td>No stem. ‘Roots’ are more like fine hairs.</td>
<td>Yes, but simple structure — flat, thick and leathery</td>
<td>No</td>
<td>No — reproduce from spores</td>
</tr>
</tbody>
</table>

### Classification

<table>
<thead>
<tr>
<th>Stem and roots</th>
<th>Leaves</th>
<th>Flowers</th>
<th>Seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes — reproduce from seeds. Seeds form inside flower, which develops into a fruit.</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes — mostly fine and needle-shaped</td>
<td>No</td>
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</tbody>
</table>

### REMEMBER

1. Explain the ways that plants differ from animals.
2. What is the main difference between bryophytes and tracheophytes?
3. Which groups of plants are called tracheophytes?
4. Which groups of plants are called bryophytes?
5. State two differences between conifers and flowering plants.

### THINK

6. Suggest why plants with vascular tissue are usually larger than ones without it.
7. A description of three plant specimens follows. Name the plant group to which each may belong.
   (a) A plant found beside a rainforest creek, without seeds or clear root system but with thick leaves
   (b) A plant with an obvious root system, a stem, leaves and with fruit containing seeds
   (c) A plant found in a cool, shady rainforest, with a horizontal stem and curled up new leaves with rows of brown spots underneath them
8. To which plant group does the plant below belong?

### SKILLBUILDER

9. Use the information in this spread to create a key that shows one way to classify plants. Start by deciding which feature best divides plants into two groups. For each group, decide what features they have in common, and how they differ. This will help you decide how to break them down further into sub-groups. If you need some help with drawing keys, check some shown earlier in this chapter.

### ICT


### I CAN:

- Explain some of the main features of plants
- Describe the different types of plant group
- Use data to create a classification key.
Most of the living things that we recognise are plants or animals. But some of the most spectacular and unusual living things belong to the other three kingdoms of living things — Kingdom Fungi, Kingdom Monera and Kingdom Prototista. Within these lesser known kingdoms are organisms that can keep us alive, make us sick or even kill us.

**Kingdom Fungi**

Fungi come in an amazing variety of shapes and colours. Perhaps the most familiar are the mushrooms we eat. But fungi also include toadstools, truffles, mould, mildew and yeast.

Fungi used to be classified as plants. However, unlike plants, they have no true roots, leaves, stems or flowers. Also, they do not contain chlorophyll. This means they cannot make their own food. Instead, they produce chemicals to break down food from outside sources. The broken-down food is then absorbed into the fungi. Different sorts of fungi feed on different sorts of food. Some grow on or in dead animal or plant matter (such as vegetable scraps, cow dung or decaying fruit) and slowly break it down (or decompose it). Some grow on or in living organisms. Such fungi are called parasites.

Fungi grow from tiny spores released by a ‘parent’ fungus. These are blown through the air, or carried by animals. Some fungi have interesting ways of releasing their spores. The Pilobolus, which lives in cow dung, releases its spores by exploding. Spores can be shot up to two metres high by the force of the explosion, which is set off by sunlight.

Some fungi cause plant diseases such as stem rot, and painful infections such as tinea and ringworm. The antibiotic penicillin is made from a fungus — so is yeast, which is used in making bread and beer.

**Under the microscope**

Members of two of the kingdoms — Monera and Prototista — are generally so small that they can be seen properly only under a microscope. To see some monerans you would even need to use the more powerful electron microscope.

**Kingdom Monera**

Monerans are thought to be the first form of life to exist on Earth. They are very simple organisms consisting of one cell without a nucleus. They are everywhere — in water, in soil, in the air and in your body. You might know them as bacteria.

Monerans can be both helpful and harmful. Some cause illnesses such as cholera and pneumonia. Some cause tooth decay. Some, such as Salmonella, can give you food poisoning. On the positive side, other monerans that live in your intestine help you to digest food and make vitamins. Others are used to make foods such as yoghurt and vinegar.

Cyanobacteria, sometimes called blue-green algae, are another member of Kingdom Monera. Like some plants, this group makes its own food using photosynthesis.

Bacteria are classified by their shape. Some are shaped like rods, some like spirals and some like spheres.
Kingdom Protoctista
This kingdom could be described as the 'leftovers'. It includes organisms that don’t belong in any of the other four kingdoms. Most protoctists are made up of only one cell. Unlike bacteria cells, the cells of protoctists have a nucleus.

Some protoctists (such as diatoms and algae) have features that are a bit like plants. Algae, for example, make their own food using photosynthesis, like a plant. Yet algae have no true roots, leaves or stems and no vascular tissue. Other protoctists, such as the blob-like Amoeba and Plasmodium which causes malaria, are more animal-like. Others are a bit like fungi, such as the one that destroyed the potato crop in Ireland in 1845–46, causing the death of about 30 per cent of the population.

An amoeba — animal-like, but only one cell

How do I classify lichen?
You will need:
piece of lichen (You will find it growing on rocks and tree trunks in colder, wetter areas, especially towards the tops of ranges and hills.)
stereomicroscope probe.

1. Describe the appearance of the lichen. Can you see two different sorts of organism?
2. Lichen is actually made up of a fungus and an alga, growing together. Which part do you think is the fungus, and which the alga? Why?
3. What benefits do you think the algal cells in lichen provide for the fungus part?
4. What benefits do you think the fungus provides for the algal cells?
5. How would you classify lichen? Why?
6. What does this suggest about the difficulties that scientists sometimes face in trying to classify organisms?

I CAN:
☐ describe the characteristics of the living things that belong to the kingdoms Fungi, Monera and Protoctista
☐ explain why it is hard to classify some organisms.