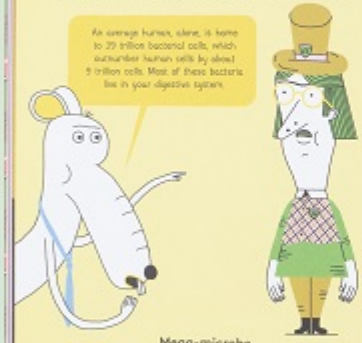
KINGDOM 2: Bacteria

Possibly 1 million or more species

☆ Abundance

Bacteria are everywhere! In the 2.5 billion years since they appeared, these microscopic single-celled organisms have evolved to exploit every environment on Earth, from icy mountain tops to deep ocean rifts. They've even been found in clouds and on the outside of the International Space Station (ISS). Despite being tiny, these marvellous microbes make up 15% of the total weight of all living things. Only plants on the planet weigh more.

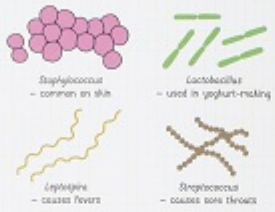


Mega-microbe

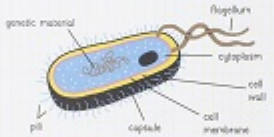
Being tiny, it took the invention of the microscope to show that bacteria existed (see page 16). The difference in size between an average bacterium and you is similar to the difference between your height and the height at which the ISS orbits Earth (more than 300 kilometres high!).

Identity parade

Bacteria come in three main shapes: spheres (cocci), rods (bacilli) and spirals. The shapes are often suggested within their scientific names, and many bacteria form distinctive clusters or chains.

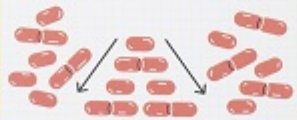


Some bacteria have whip-like 'tails', called 'flagella', to propel themselves. They may also have hair-like projections called 'pili' and an outer coating (capsule), both of which can make them more aggressive in causing disease, and also harder to destroy.



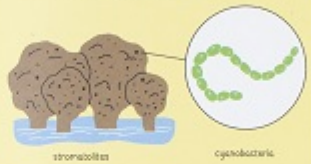
On the double

Most bacteria reproduce by growing, copying their genetic material and then splitting in two. *Escherichia coli* (often called, simply, 'E. coli'), a bacterium found in our stomachs, can double its numbers every 20 minutes in ideal conditions.



On the menu

Bacteria have an amazing range of foods: living things, dead things, rocks, minerals, oils, plastics, and us! When they grow on or inside other organisms they can cause diseases, some of them seriously harmful. However, special bacteria called cyanobacteria get their energy from photosynthesis, producing oxygen in the process. Billions of years ago, they are thought to have radically changed Earth's atmosphere to one richer in oxygen, more like the air we breathe today. Rocky mounds ('stromatolites') formed by cyanobacteria on the Australian coast are the oldest evidence of life on Earth, dating back at least 3.4 billion years.



Poo and you

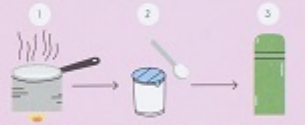
Some (unlucky) microbiologists have measured 100 billion bacteria – half of which were still alive – in a single gram of human poo. While these bacteria are fine inside us – and down the loo – spreading them around is a bad idea. Always wash your hands!

Say 'cheese!'

Many fermented foods are made using harmless bacteria, including yoghurt, sauerkraut, kimchi, kefir and soy sauce. Bacteria produce the blue veins in Stilton and Roquefort cheeses and the tastes and textures of many classic cheeses, including Camembert, Gruyère and Brie. *Spirulina*, a cyanobacterium, is sold dried as a health supplement.

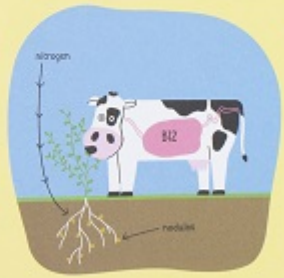
Grow your own yoghurt

Bring a pan of whole milk almost to the boil (get a grown-up to help), then let it cool to body temperature. Stir in a big spoonful of live yoghurt (check the label), then pour it all into a clean vacuum flask and seal it. Leave it for a day or so and the bacteria will grow and thicken the milk to make yoghurt. Keep it in the fridge after opening.



Food for thought

Bacteria are a vital part of the food chain. Some bacteria form special bumps, called 'nodules', in the roots of plants, such as beans and peas. The bacteria take nitrogen from the air and use it to form amino acids, the building blocks of proteins. Other bacteria in the stomachs of cattle and sheep produce vitamin B12, essential for health. People can get this B12 from meat and dairy products, but vegetarians and vegans sometimes need to take a special supplement.



SIGNS OF LIFE

- ☐ YOGHURT
- ☐ CHEESES
- ☐ SAUERKRAUT
- ☐ KIMCHI
- ☐ SPIRULINA
- ☐ ME
- ☐ YOU
- ☐ POO
- ☐ EVERYWHERE!

KINGDOM 5: Planta

Over 390,000 species

☆ Turning light into life

The study of plants is called botany, and botanists know that all plants are wonderful – even weeds! Without plants, pretty much all life on Earth would cease to exist.

Plants sit at the bottom of a pyramid of living things known as a food chain. Plants grow and get eaten by animals, passing on their energy. Other animals eat those animals. When all these organisms eventually die, they are eaten and decomposed by bacteria, fungi and yet more animals. Eventually, this energy returns to nature and the whole process goes around again!

Plant power

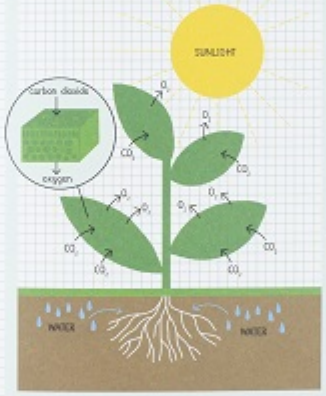
Plants are plentiful! They make up 80% of the total mass of life on Earth and are found on every continent, including Antarctica. All animals – including humans – rely, ultimately, on plants. Plants feed us, clothe us and provide the materials for tools, shelter and medicines. Plants also produce the oxygen we need to breathe, and take harmful carbon from the atmosphere so it can't contribute to climate change.

Plants are also incredible invaders! They colonise newly exposed areas on Earth to form brand-new habitats, allowing other organisms to follow. Different plants produce different habitats, resulting in the huge variety of living things to be found on Earth – an idea known as 'biodiversity'.

Light fantastic

Photosynthesis is how plants trap the energy in sunlight to make their own food. Special organelles called 'chloroplasts' in the cells of leaves use this energy to combine carbon dioxide (CO_2) from the air with water (H_2O) from their environment to produce sugars and oxygen (O_2). The oxygen is released into the air and the sugars are used to feed the plant and build new cells.

Chloroplasts contain a pigment called 'chlorophyll'. This absorbs only red and blue light, and reflects green light, which is why plants appear green!



Shine on

You can show photosynthesis at home by submerging some fresh watercress or spinach in cold water. Shine a strong light on the leaves and small bubbles of oxygen should eventually appear.

Leafy lunch

Not keen on greens? A meaty fast-food feast is ultimately entirely due to plants. Sadly, it still doesn't count towards your five a day. And, of course, there will be bacteria too!

The green scene

Plants have been around for over 500 million years. Today, they range from tiny single-celled green algae (see page 22) to giant trees such as redwoods (see page 25) that are among the heaviest living things on the planet. Some are poisonous, some are pretty and some are pretty strange!

KINGDOM 7: Animalia

Over 1.5 million known species

☆ Munching and moving

The study of animals is called zoology. Animals are often very visible organisms, moving in a multitude of ways in, over and across the globe. They range in size from microscopic to mighty, but all are multicellular eukaryotes (see page 6) with a need to feed.

Skeleton crew

Animals divide informally into two groups: those with an internal skeleton to hold them up ('vertebrates') and those without ('invertebrates'). Invertebrate 'creepy-crawlies' make up 97% of all known animal species, and nine out of ten of them are insects (see pages 42–43). Humans are massively outnumbered!

Mirror image

Most animals – including you – are essentially tubes, where food enters at one end and wastes exit at the other. Many show bilateral symmetry, where the left and right sides of the body are mirror images. Most have a mouth. Many have their major sensory organs organised into a head at one end. Sponges, jellyfish and starfish are some exceptions and show radial symmetry, like equally slicing up a pizza.

butterfly (bilateral symmetry) · starfish (radial symmetry) · jellyfish

You are what you eat

Animals have evolved a vast variety of strategies for finding food – and staying alive long enough to reproduce – giving us the staggering range of species we see today. Animals that eat plants are known as 'herbivores'. Flesh-eating animals are called 'carnivores'. Animals that eat a mix of things – such as humans – are known as 'omnivores'. But, of course, in nature, nothing ever goes to waste, so there are also animals that eat such treats as poo, and dead and rotting animals and plants. These are 'scavengers' and 'detritivores'. They all have an important place in the food chain (see page 20).

What a nerve!

Unlike plants and fungi, the cells of animals lack rigid walls. In the 500 billion years since they first appeared, animals have evolved all sorts of cells with different functions. Most are microscopic, but if you want to know what the longest single cell in the human body is, the answer is on page 7!

Hot or cold

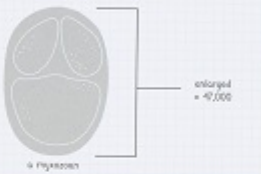
'Warm-blooded' mammals and birds are the only animals capable of maintaining a constant body temperature. All other animals are said to be 'cold-blooded' – their body temperature relies on their environment. Too cold and they cannot move or function correctly. Too hot and they die.

Hot to trot

Borrow a medical thermometer and take your temperature at intervals through the day. It should stay around a healthy 37°C – the best temperature for the chemical processes that take place in cells.

Little and large

The smallest animals currently known are tiny fish parasites called myxozoa. Distant cousins of sea jellies, they are just one-hundredth of a millimetre in size. In complete contrast, the blue whale is not only the largest living animal, but also the largest animal that has ever existed. The longest blue whale measured topped the tape at 33.5 metres – just pipping the dinosaur *Diplodocus*!



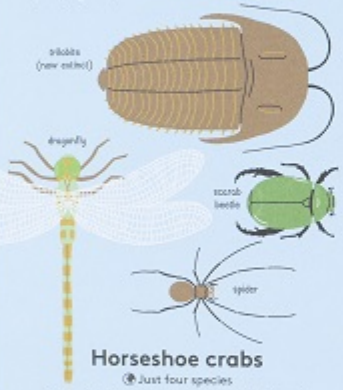
All together now

Animal species have many different ways of getting together – or not, as the case may be! Some are loners. Giant pandas, for example, spend most of their lives solo and meet up only to mate. Birds, antelopes and fish form flocks, herds and shoals respectively, relying on safety in numbers. Insects such as bees and termites live in complex colonies where individuals work together, often with different jobs.

Human social groups are so complex that today we can even interact with people we have never met!

Arthropods: Shake a Leg

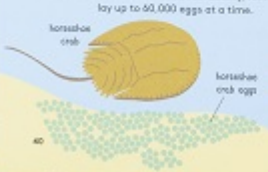
Arthropod means 'jointed foot'. The members of this group have pairs of jointed limbs, a hard outer skeleton ('exoskeleton') and segmented bodies. Sea-dwelling trilobites were an early member, over 500 million years ago. Today the group is split into five main gangs: horseshoe crabs, arachnids, myriapods, crustaceans and insects **(see page 42).**



Horseshoe crabs

Just four species

These are not actually crabs but 'living fossils' largely unchanged since they evolved 450 million years ago. The shape of their shells gives rise to their common name. Horseshoe crab eggs are an important food for fish, turtles and seabirds. Luckily, females lay up to 60,000 eggs at a time.



Arachnids

Over 100,000 species

This arthropod group includes ticks, mites, scorpions and – most famously – spiders. Most arachnids have eight legs, a body in two parts and no wings, and almost all live on land or as parasites. Although spiders and scorpions can look scary, it is actually only tiny mites and ticks that might feed on us.

The Mexican redknee tarantula is a popular pet, and rarely bites!

Mexican redknee tarantula

Spider v. bee

Fear of spiders is called arachnophobia, but they only ever bite in defence and most can't pierce our skin with their fangs. The funnel web spider of Australia is one of the world's most venomous spiders, yet a recent survey showed no deaths from spider bites in the country, compared to 25 deaths from bee stings.

funnel web spider

Put your foot in it?

Most scorpions have a front pair of pincers and a venomous stinger at the tip of a curving tail. Found in warm countries, they hunt other animals at night – seizing prey with their pincers and stinging to paralyse it.

Of over 1,000 species, only about 25 are harmful to humans, and that is mostly by accident – such as when someone puts on a shoe with a scorpion inside. Check first!

The deathstalker scorpion is one of the deadliest, and often illegal to keep as a pet.

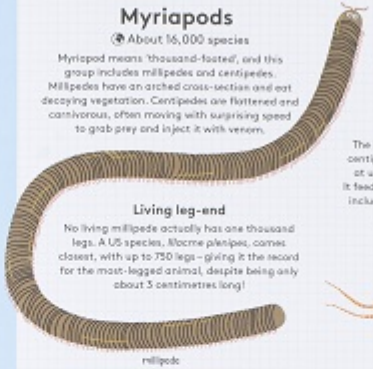
SIGNS OF LIFE:

- ☐ ALMOST ENTIRELY ON LAND
- ☐ CHECK YOUR SHOES!

Myriapods

About 16,000 species

Myriapod means 'thousand-footed', and this group includes millipedes and centipedes. Millipedes have an arched cross-section and eat decaying vegetation. Centipedes are flattened and carnivorous, often moving with surprising speed to grab prey and inject it with venom.



Living leg-end

No living millipede actually has one thousand legs. A US species, Illacme plenipes, comes closest, with up to 750 legs – giving it the record for the most-legged animal, despite being only about 5 centimetres long!

False legs

All centipedes have an odd number of pairs of legs, meaning none of them can have exactly 100 legs in total. 98 or 102 is the closest you can get.

The Peruvian giant yellow-leg centipede is the world's largest, at up to 30 centimetres long. It feeds on anything it can catch, including bats, and its bite can even kill humans.

SIGNS OF LIFE:

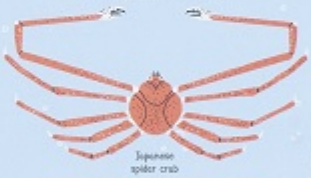
- ☐ DAMP-LOVING LAND-DWELLERS
- ☐ OLD JOKES!

Crustaceans

Over 67,000 species

Most crustaceans are aquatic animals with hard chalky shells, such as crabs, shrimps, prawns, crayfish and lobsters. The humble woodlouse lives on land, but even it prefers damp places. Zillions of paperclip-sized crustaceans called krill inhabit the world's oceans and are a vital food for everything from jellyfish to whales. Humans harvest and eat krill too, as well as enjoying larger species of crustacean as seafood.

The Japanese spider crab is the world's largest arthropod, with a leg-span of 3.5 metres!



The lobsters some people eat are actually blue in the wild. A pigment in their shells changes colour when they are cooked, turning them 'lobster pink'.

Hermit crabs reuse abandoned mollusc shells as their homes, trading up to a larger size as they grow!

SIGNS OF LIFE:

- ☐ BEACHES
- ☐ SEAS
- ☐ DAMP SPOTS
- ☐ FORESTS
- ☐ FISHMONGERS

LIFE STORIES

THE CASE OF THE DANGEROUS DARWIN 8