

KINGDOM 2: Bacteria

Approximately 1 million or more species

Microscopic

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-sea vents. They've even been found in clouds and on the outside of the International Space Station (ISS). Despite being tiny, these marvelous microbes make up 16% of the total weight of all living things. Only plants on the planet weigh more.

No single human diet is home to 25 trillion bacterial cells, which is similar to the cells in your body. In other words, you are what you eat.



Meigs microscope

Being tiny, it took the invention of the microscope to show that bacteria existed (see page 34). The difference in size between our average bacterium and you is similar to the difference between your height and the height of an adult blue whale (both measured from the nose to the tail).



Identify 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 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

Many bacteria reproduce by growing, splitting their genetic material and then splitting in two. Bacteria that split (often called, simply, 'E. coli'), a bacterium found in our intestines, 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, oil, plastic, and so on. When they grow on or inside other organisms they can cause disease, some of them seriously harmful. However, special bacteria called symbionts 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. Every mouthful of greenery (or 'photosynthesis') formed by symbionts on Earth has created the entire web of life on our planet, dating back at least 3.4 billion years.



Poo and you

Some (pinkish) microorganisms have trillions of bacteria: a half of which were still alive in a single gram of human poo. When these bacteria die, they make us—and down the loo—smelling there around is a bad idea. Always wash your hands!



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.



Say 'cheese!'

Many fermented foods are made using bacteria. Bacteria, including yeasts, are used to make bread, beer, and many other foods. Bacteria produce the blue veins in Stilton and Roquefort cheeses and the taste and texture of many other cheeses, including Camembert, Gorgonzola, and Brie. Bacteria in kombucha, a cold drink, is sold as a health supplement.



Grow your own yoghurt

Bring some of whole milk straight to the boil (get it growing up/boiling), then let it cool to body temperature. Use an airtight spoon to fill the yoghurt (check the label), then pour it into a clean jar or bottle. Seal and wait. 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.



20 MARKS OF USE

- ☐ 10 MARKS
- ☐ 20 MARKS
- ☐ 30 MARKS
- ☐ 40 MARKS
- ☐ 50 MARKS
- ☐ 60 MARKS
- ☐ 70 MARKS
- ☐ 80 MARKS
- ☐ 90 MARKS
- ☐ 100 MARKS

KINGDOM 5: Planta

Over 300,000 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 powerful! They make up 80% of the total mass of life on Earth and are found in every environment, including Antarctica. All animals—including humans—rely, ultimately, on plants. Food is eaten as fuel and provides the materials for health, shelter and medicine. Plants also produce the oxygen we need to breathe, and today humanity couldn't survive anywhere as it can't contribute to climate change.

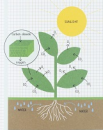
Plants are also incredibly involved! They collect newly exposed areas on Earth to their benefit, new habitats, allowing other organisms to follow. Different plants produce different habitats, resulting in the huge variety of living things to be found on Earth—an idea known as 'biodiversity'.

Plants dream up things.
Right or dead and then
some flowers!

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 more cells.

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



Shine on

You can show photosynthesis at home by taking away some fresh vegetables or spinach in mist water. When a strong light on the leaves and small bubbles of oxygen should eventually appear.

Leafy lunch

Not many are green! A steady food food forest is a fantastic idea due to plants. Sadly, it still doesn't count towards your five a day. And, of course, there will be vegetables too!



The green scene

Plants have been around for over 500 million years. Today, they range from tiny single-celled green algae (see page 24) to giant trees such as redwoods (see page 25). That is, among the fastest living things on the planet. Some are poisonous, some are pretty and some are pretty strange!

Some fly traps -
see page 25!



KINGDOM 7: Animalia

Over 1.5 million animal 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 4) with a need to feed.

Skeleton crew

Animals divide internally into two groups: those with an internal skeleton to hold them up ('vertebrates') and those without ('invertebrates'). Invertebrates (invertebrates) make up 95% of all known animal species, and live out of two of them are insects (see page 40-41). Humans are invertebrates too!



Mirror image

Most animals (including you) are **bilaterally symmetrical**, where both sides of one end and across an imaginary line show identical symmetry, where the left and right sides of the body are mirror images. Most have a mouth. Many have their major sensory organs organized into a head at one end. Sponges, jellyfish and starfish are some exceptions and show radial symmetry. See exactly where you fit in.



butterfly
(bilateral symmetry)



starfish
(radial symmetry)



jellyfish

You are what you eat

Animals have evolved a vast variety of strategies for feeding food – and eating it in a way enough to reproduce, giving us the staggering range of species we see today. Animals that eat plants are known as **herbivores**. From eating animals are called **carnivores**. Animals that eat a mix of things – such as humans – are known as **omnivores**. But, of course, it's not just what you eat that matters, as there are also animals that eat each other to live, and need everything animals and plants. These are **scavengers** and **decomposers**. They all have an important place in the food chain (see page 20).



elephant – herbivore



hawk – carnivore



you – omnivore



big cat – carnivore

What a nerve!

Unlike plants and fungi, the cells of animals feed right into. In the 100 billion years since they first appeared, animals have evolved all sorts of cells with different functions. Most are **nerve cells**, but if you want to know about the longest single cell in the human body, it's the axon in the nerve cell.



nerve cell

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 rises as their surroundings. Too cold and they cannot move or function correctly. Too hot and they die.



warm-blooded

cold-blooded

Hot to trot

Warm-blooded mammals and birds can regulate their body temperature through the day. It should stay around a healthy 37°C – the best temperature for the chemical reactions that take place in cells.

Little and large

The smallest animals currently known are tiny fish, animals called **nanoplankton**. Bigger animals are called **macroplankton**. 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 largest blue whale measured topped the top at 33.5 metres – just appearing on the horizon!



All together now

Animal species have many different ways of getting together, or not, as the case may be. Some are **solitary**. Others, for example, spend most of their lives alone and meet up only to mate. Bees, wasps and fish have **hives**, **colonies** and **schools**, respectively, staying in solitary in numbers. Bees such as bees and honey bees 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 300 million years ago. Today the group is split into five main groups: horseshoe crabs, arachnids, myriapods, crustaceans and insects (see page 43).



Horseshoe crabs

⚡ Over four species

These are not actually crabs but "living fossils" largely unchanged since they walked with trilobites over 300 million years ago. The shape of their shells goes all the way back to their common ancestor. Horseshoe crabs are an important food for fish, turtles and seabirds. Luckily, females lay up to 85,000 eggs in a time.



Arachnids

⚡ Over 100,000 species

This enlarged group includes ticks, mites, scorpions and "true" spiders. Most arachnids have eight legs, a body in two parts and no wings. And almost all live on land or in ponds. Although spiders and scorpions can look scary, it is actually only tiny ticks and ticks that might threaten us.



The Mexican centipede tarantula is a popular pet, and rarely bites.



Spider vs. bee

Fear of spiders is called arachnophobia, but they only use their defence and most can't poison us like with their fangs. The funnel web spider of Australia is one of the world's most venomous spiders, yet it would never show us deadly fangs. Spiders in the country compared to 12 deaths from bee stings.



Put your foot in it!

Most scorpions have a front pair of pincers and a venomous sting at the tip of a tail-like structure. Found in warm countries, they hunt other animals at night - warning you with their pincers and stinging to paralyze it.

Of over 1,000 species, only about 25 are harmful to humans, and that is mostly by accident - such as when someone puts an arachnid on a sensitive scalp.

Check that!

The scorpion is a member of the scorpion family. It is a member of the scorpion family. It is a member of the scorpion family.



⚡ About 100,000 species

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⚡ About 100,000 species

Myriapods

⚡ About 10,000 species

Myriapods means "thousand-footed", and this group includes millipedes and centipedes. Millipedes have an arched, oval body and many pairs of legs. Centipedes are flattened and sometimes, often missing with burrowing species to get away and inject it with venom.



Living leg-wad

Living myriapods actually have one thousand legs. A US species, the centipede, is about 10 cm long, with up to 170 legs - giving it the record for the most legs of any animal, despite being only about 1.5 centimetres long!

False legs

All centipedes have an odd number of pairs of legs, meaning some of them have false legs. Centipedes have a total of 40 or 100 legs, which you can get.



The Peruvian giant centipede is the world's largest, at up to 30 centimetres long. It feeds on anything in its path, including bats, and has been seen kill humans.

⚡ Signs of life

⚡ Signs of life

Crustaceans

⚡ Over 47,000 species

Most crustaceans are aquatic animals with hard, chitinous shells, and no wings, stings, pincers, or venom. The humble crayfish lives on land, but most crustaceans are found in water. Crustaceans are called "crustaceans" because they are found in the world's oceans and are a vital food for everything from jellyfish to whales. Crustaceans are not just for the sea - many species of crustaceans are found on land.



The lobster is a member of the crustacean family. It is a member of the crustacean family. It is a member of the crustacean family.

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The Japanese spider crab is the world's largest crustacean, with a leg span of 3.5 metres.



⚡ Signs of life

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⚡ Signs of life

⚡ Signs of life



LIFE STORIES

REMEMBER THAT A BIRD'S FEET ARE BUILT TO GRASP, A HAND IS BUILT TO GRASP, A TOOL IS BUILT TO GRASP.



SCIENTIFIC ADVANCEMENT ONLY HAS ONE ENEMY: ILLITERATION.



THE TOOL TOOL



ALL THAT THE PROGRESS EVOLUTION HAS BRINGS WITH IT IS THE PROGRESS OF 'IMPROVEMENT'.



BUT NOW WE'VE GOT TO GO BACK TO THE BEGINNING.



THEORY: THE MORE WE KNOW, THE MORE WE KNOW.



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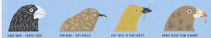


THEORY: THE MORE WE KNOW, THE MORE WE KNOW.



THE CASE OF THE DANGEROUS DARWIN 8

EVERYTHING WAS FINALLY SETTLED IN 1881, INCLUDING THE CASE OF THE DANGEROUS DARWIN.



THEY WERE ALL IN THE SAME PLACE, AND ALL OF THEM WERE IN THE SAME PLACE.



THEORY: THE MORE WE KNOW, THE MORE WE KNOW.



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