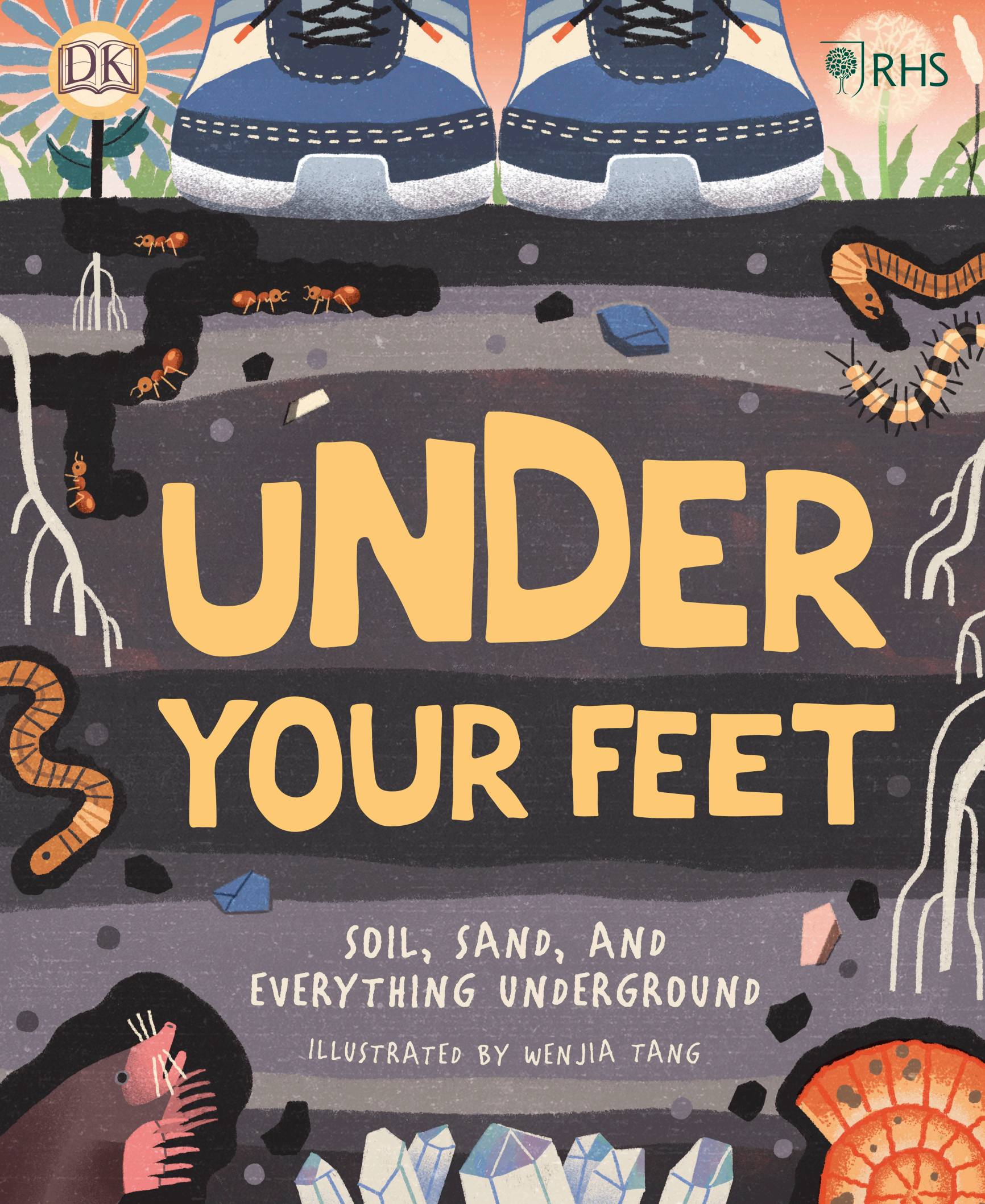
DK
RHS
UNDER YOUR FEET
SOIL, SAND, AND EVERYTHING UNDERGROUND
ILLUSTRATED BY WENJIA TANG

UNDER YOUR FEET

Written by **Dr Jackie Stroud**
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Illustrated by **Wenjia Tang**

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WHY DO WE NEED SOIL?

We often brush soil off newly bought mushrooms and vegetables. These are some of the foods that use the nutrients and water stored in soil to grow. Soil has lots of other important jobs, too, from holding up houses to cleaning water.

Filtering water

Soil is the largest water filter on Earth. As water flows downwards through the soil, small pores (openings) trap murky bits in the water. Soil also takes in some harmful substances that have made it into the water.

Getting rid of waste

Living things in soil eat organic waste and release it as nutrients into the soil, which help plants grow.


The leaves of trees release oxygen.
Saving the planet
A gas called carbon dioxide (CO_2) traps heat in the air and makes our planet warmer. Soils store carbon (found in CO_2), so protecting them could help slow global warming.
Foundations
Cracks can appear if part of the house starts to sink.
Houses are built on foundations that are dug into the soil. If the soil becomes unstable then foundations can slip and the house may start to sink.
Food
Many animals need soil-growing plants to eat. In turn, other animals need to eat those animals to survive.
Green spaces
Green spaces are full of plants that absorb CO_2 and release oxygen. Soil creates a sturdy foundation for roots. It provides a store of nutrients and water that plants use to grow.

Capture carbon

Carbon is found as a solid and in CO_2. Solid carbon is found in trees, and is released into the soil when they rot. It can more easily become CO_2 from the soil. Making some trees into furniture can actually lock the carbon up for longer!

Tread lightly

We create greenhouse gases by driving or walking on wet soils. Air is squashed out of the soil, which leads to more nitrous oxide and methane in the air.

Grow things

Plants change CO_2 into solid carbon, such as sugars, to make their leaves and roots. When they die, the carbon becomes part of the soil.

Plants feed soil microbes with carbon from their roots.

The atmosphere is a layer of gases around the Earth.

GLOBAL WARMING

Soils help to keep our planet at the right temperature – not too hot or cold. Soils can produce greenhouse gases that make climate change worse. However, we can help soils to soak up these gases by looking after the ground.

Make airy compost

Most nitrous oxide and methane is made by microorganisms that do not have enough oxygen (a gas found in the air). Compost heaps need lots of dry leaves, twigs, and other materials that let in air for the microorganisms to breathe.

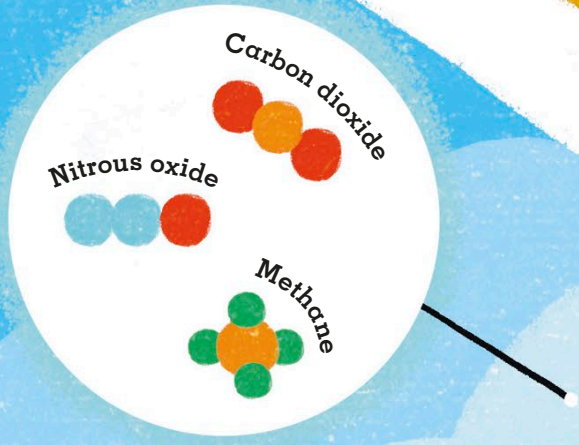
Farm wisely

Farmers plough soil to kill weeds. Ploughing also breaks the soil up, which releases nutrients to help seeds grow. However, too much ploughing destroys soil life and releases greenhouse gases. Many farmers are choosing to plough less to help solve this problem.

It is warmed by the Sun's rays.

Greenhouse gases

The Earth is heating up, which causes fires, droughts, and floods. We call this global warming. The three main "greenhouse" gases that cause it are carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4).

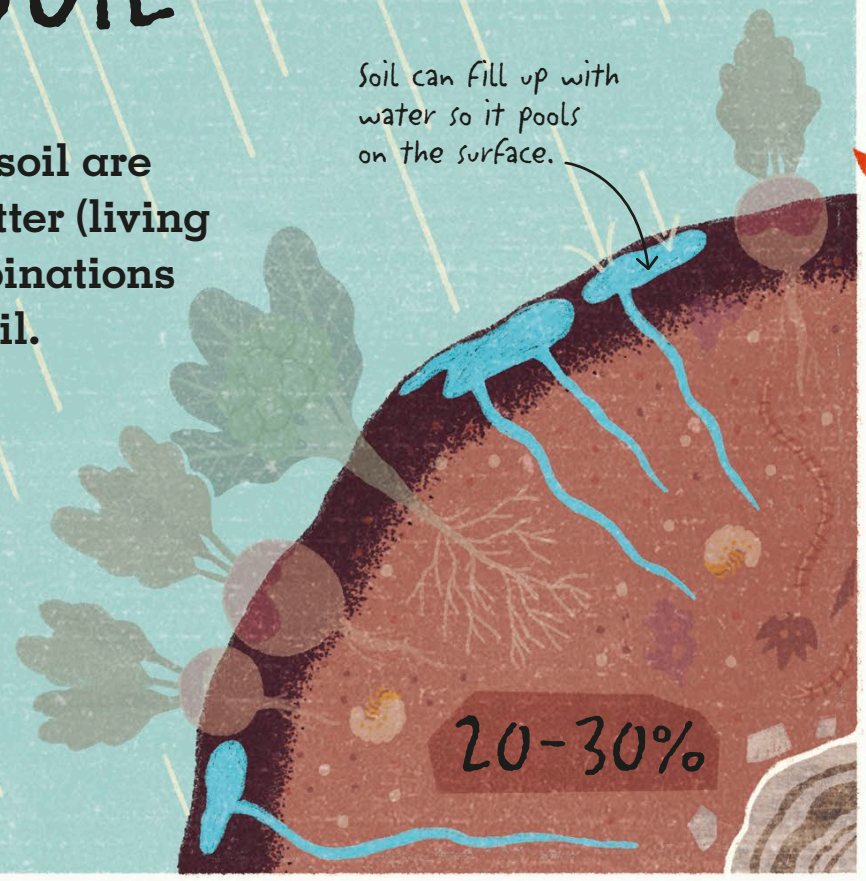


THE STUFF OF SOIL

Soil is like a cake mix – made up of ingredients. The four ingredients in soil are minerals, water, air, and organic matter (living or once-living things). Different combinations of each make up different types of soil.

Water

Water soaks into the soil after rain. Minerals and nutrients dissolve into the water to form a soil solution. Most water drains through burrows and cracks, but some will remain in small spaces between soil particles, called pores.



Organic matter

Living roots and millions of soil organisms, from microscopic fungi to creepy crawlies, are all organic matter. This also includes dead things, such as leaves that are decaying (breaking down).

In overly wet soils, water fills airy spaces.

Air

Organisms live and grow best in soils with almost equal amounts of air and water, which they need to survive. Air moves through the soil in cracks, burrows, and pores.

Centipedes take in air through holes along their bodies.

20-30%

Beetles begin their lives underground, where they need air to breathe.

Bedrock

45%

Clay

Sand

Silt

Turnips grow well in loose, sandy soils.

Minerals

A mineral is a solid that is found naturally and made of crystals. In soil, the gritty mineral ingredient includes particles called sand, silt, and clay. Some plants grow well in sandy soils, but others prefer soils with lots of clay particles.

Soil minerals are worn away from rocks on the surface and from bedrock.

Sand particles can be 1,000 times bigger than clay.

SOIL HORIZONS

Our lifetimes are short compared to the thousands of years it can take for soil to form into layers, called horizons. Soil can stretch down for 50 m (164 ft).

Millipedes and other soil dwellers eat humus for its nutrients.

Humus

The top portion of soil is called humus. This dark horizon is made of dead things that have decayed (broken down).

Topsoil

You might have seen the mid-brown topsoil layer if you've planted seeds near the surface of soil. This mixture of dead matter, minerals, and small rock fragments is where most soil animals live.

Subsoil

A lot of digging would reveal this pale layer. Amongst tree roots, there are minerals and materials carried down by rainwater from above.

Mineral spotting

Hematite

Sodalite

Small creatures can leave their outlines in bedrock.

Regolith

Digging starts to get difficult in the deep, substratum layer. This horizon is full of minerals and large rock fragments. Bits of these become the material in the upper layers.

Bedrock

Anyone tunnelling down into the soil would eventually hit this solid slab of rock with a bang. Bedrock has not been broken down by wind or rain, unlike surface rock.

Bedrock is not soil, and always sits beneath the horizons.

SOIL CITY

Around a third of all creatures on the planet live in soil. Most rely on their fellow soil-dwellers for food. Some poo out nutrients for plants to eat. Scientists often group the animals together by size.

Slugs

Hyphae are the skinny bits of fungi that absorb soil nutrients.

Plant root

Fungi and plants

Fungi release chemicals, called enzymes, which break down dead plants into nutrients. The fungi, as well as plants, can then absorb these nutrients to grow.

Springtails can spring (jump) as high as a pencil.

Mites are the fastest-running land animal for their size.

Earthworms

These wrigglers eat dead plants and make poo containing lots of nutrients. Soil organisms eat the poo to get the nutrients.

Moles burrow to catch unsuspecting worms.

Moles

You may never see a worm-guzzling mole because it spends most of its life below ground. However, piles of freshly dug soil are a sign of moles beneath.

Minibeasts

You can spot small creatures called minibeasts if you crouch close to the ground. These include marching ants, scuttling centipedes, and gliding slugs.

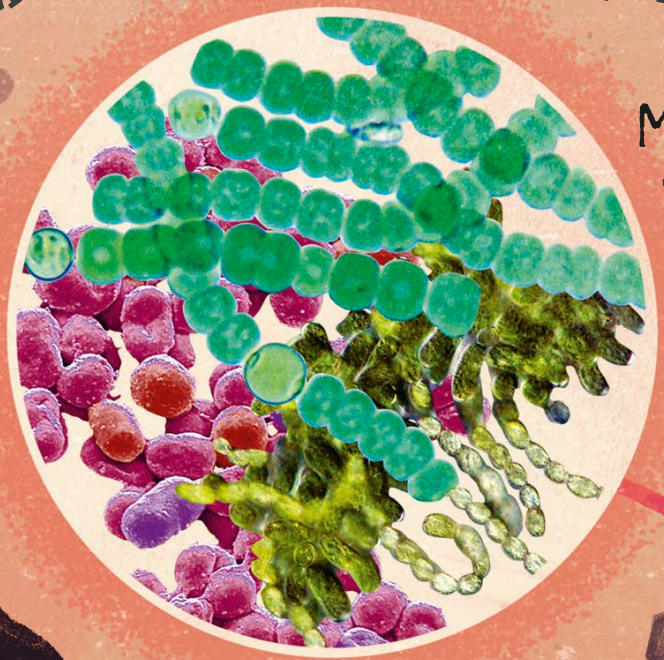
Centipedes hunt insects and slugs by pouncing and injecting venom from their legs.

Burrowing creatures bulldoze or dig their way through soil.

Mesofauna

There are tens of thousands of tiny, dot-sized soil animals called mesofauna. These include sprinting mites and leaping springtails.

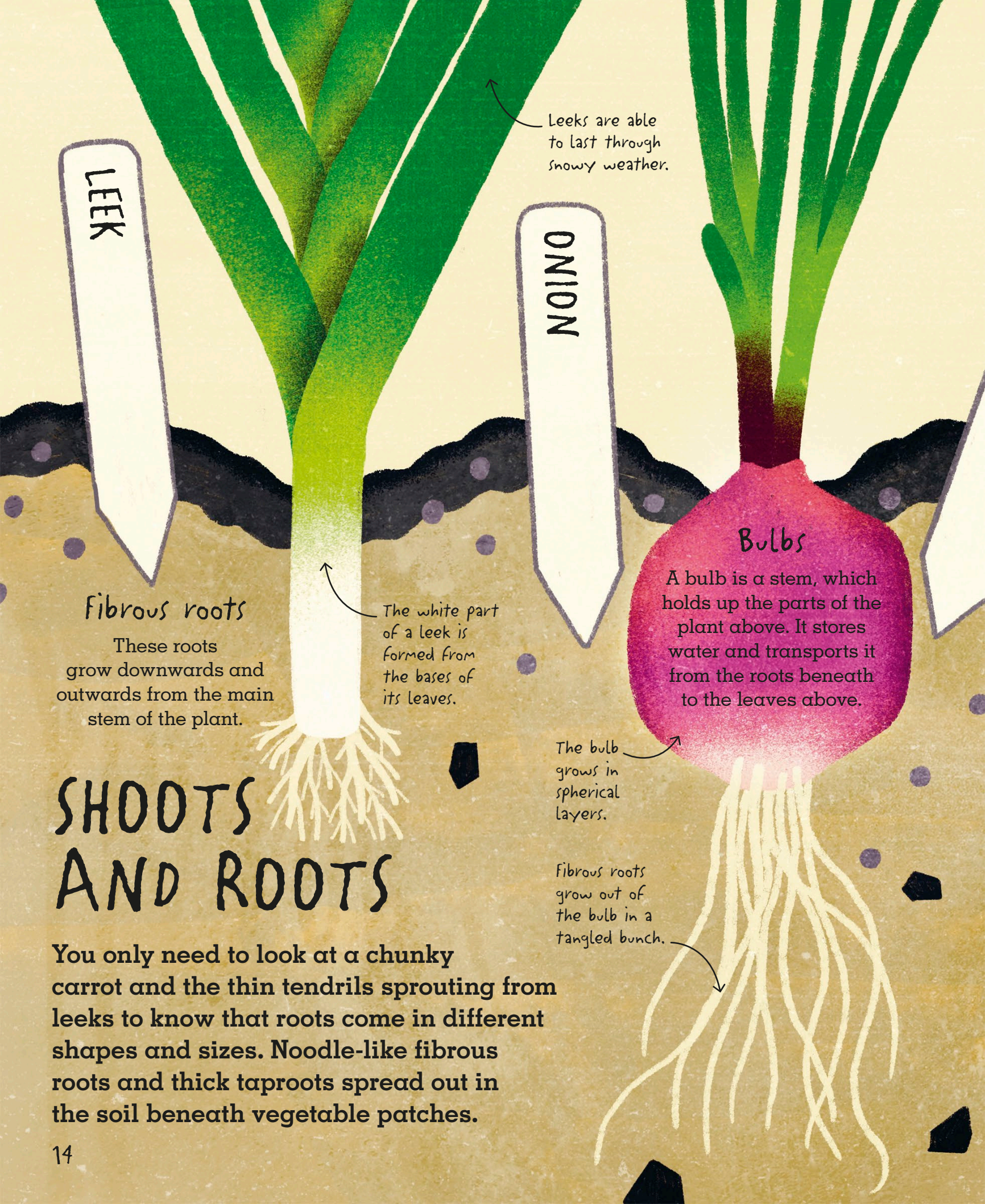
Microorganisms are an important part of the earthworm diet.



Microorganisms

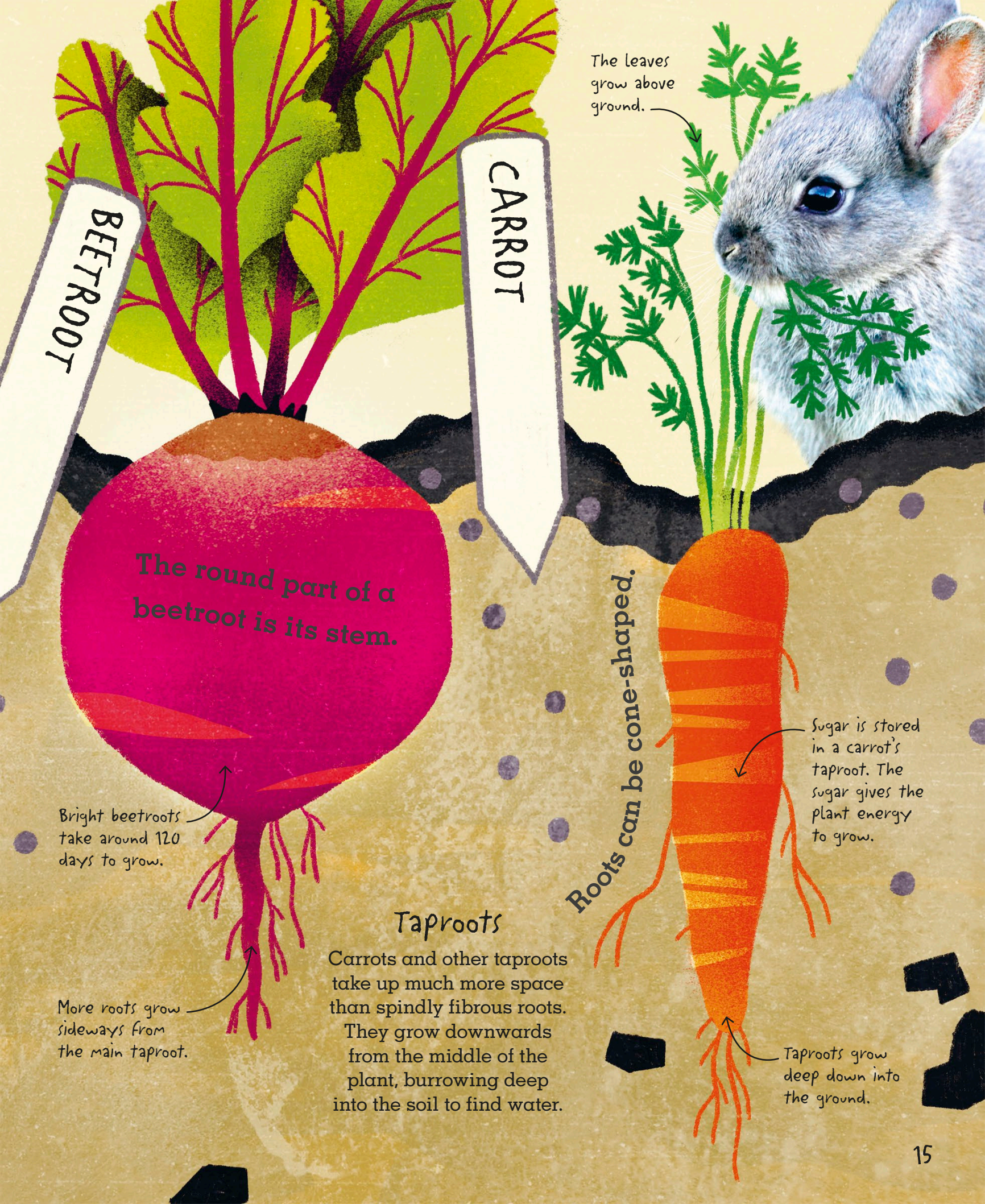
The smallest soil dwellers are microorganisms. A microscope is needed to see almost all the bacteria and fungi that make up this group. There are billions of them in one spadeful of soil.

Most millipedes have fewer than 100 legs.



SHOOTS AND ROOTS

You only need to look at a chunky carrot and the thin tendrils sprouting from leeks to know that roots come in different shapes and sizes. Noodle-like fibrous roots and thick taproots spread out in the soil beneath vegetable patches.



Taproots

Carrots and other taproots take up much more space than spindly fibrous roots. They grow downwards from the middle of the plant, burrowing deep into the soil to find water.

GROWING FOOD

The fruits, vegetables, beans, and cereals that fill our plates all need healthy soil to grow. Farmers take great care of the soil used for their crops.

Slugs and other pests eat crops and earthworms.

In healthy soil, there are creatures such as beetles to eat pests such as slugs.

Health check

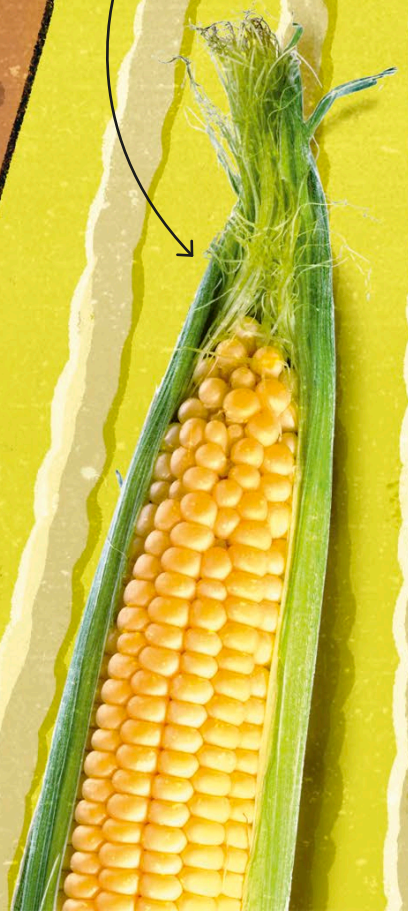
Good soil feels crumbly and has plenty of earthworms. Farmers dig holes to check their soil is healthy for growing crops.

Sowing seeds

Seeds are planted at an exact depth. Too shallow, and birds will gobble them up. Too deep, and the seedlings won't grow!

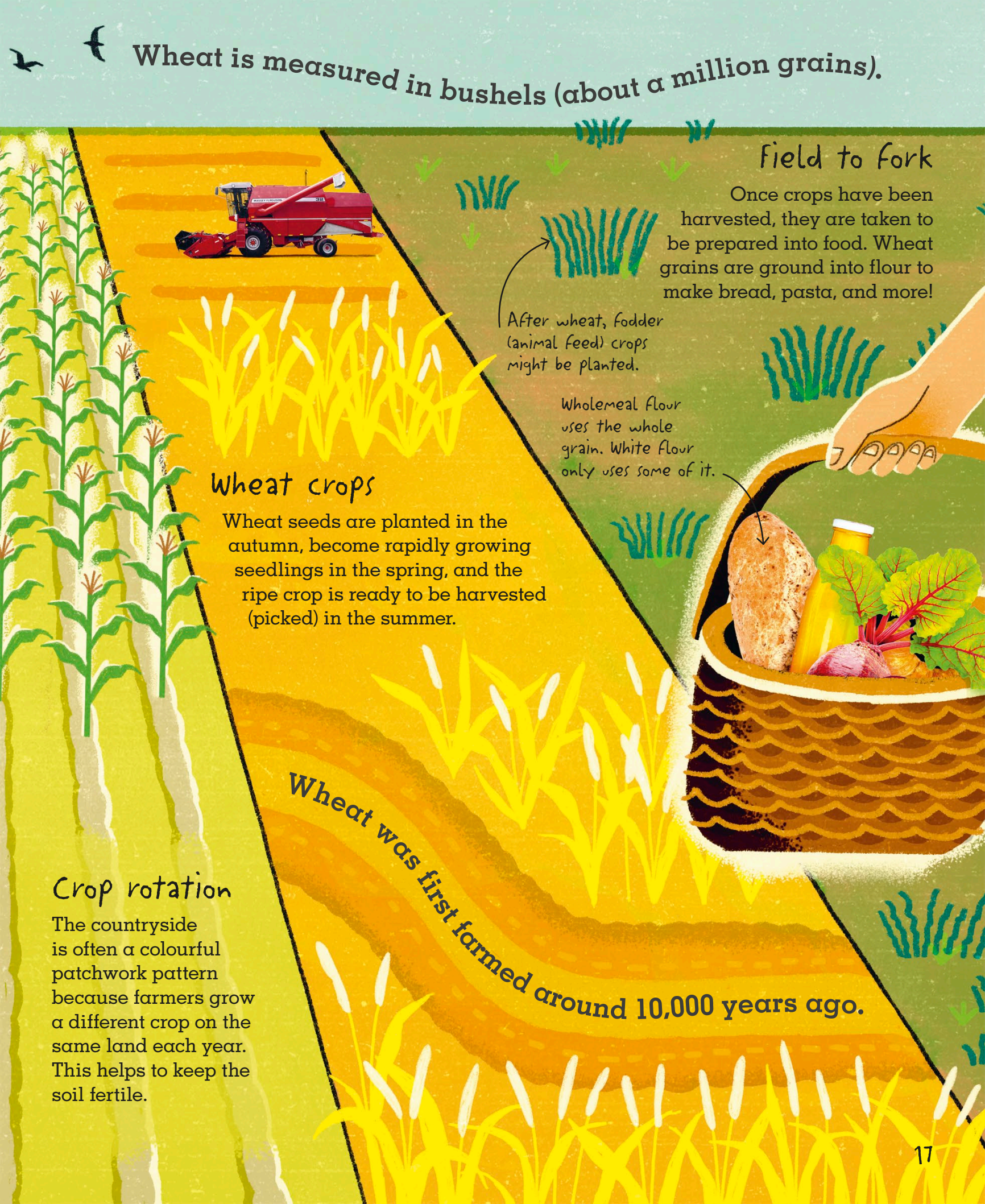
Scarecrows can frighten off birds that have their greedy eyes on the seeds.

Maize can be ground into flour and used to make flatbreads called tortillas.



China produces the most wheat in the world.

Wheat is measured in bushels (about a million grains).



Field to Fork

Once crops have been harvested, they are taken to be prepared into food. Wheat grains are ground into flour to make bread, pasta, and more!

After wheat, fodder (animal feed) crops might be planted.

Wholemeal flour uses the whole grain. White flour only uses some of it.

Wheat crops

Wheat seeds are planted in the autumn, become rapidly growing seedlings in the spring, and the ripe crop is ready to be harvested (picked) in the summer.

Crop rotation

The countryside is often a colourful patchwork pattern because farmers grow a different crop on the same land each year. This helps to keep the soil fertile.

Wheat was first farmed around 10,000 years ago.

Birds catch worms to feed their chicks.

A WORM'S WORK

Earthworms do lots of hidden jobs, especially in the spring and the autumn. This is when most soils are warm and moist. The three main earthworm types are surface worms, topsoil worms, and deep burrowers.

Different types of earthworm live at different depths.

Leaf decomposers

Red surface worms usually grow to the size of a matchstick. These worms feed on dead leaves near the soil surface. They poo the nutrients from the leaves into the soil.

Surface worms live on top of the soil.

Wildlife food

Earthworms are an important food for wildlife such as birds and foxes. Foxes catch up to 10 juicy worms a minute.

Off-duty worms

Soil can become too dry for earthworms. Then, the worms make small chambers, and curl up into tight knots to rest and avoid losing moisture. This can be for days or months, until the soil conditions improve.

Mucus-lined chambers help worms survive the summer.

Plant chefs

Pale topsoil worms eat soil, and poo it out in a different form. Plants absorb this as food. Topsoil worms can be more than three times as long as surface worms.

Plant food

Plants can't just take in other plant matter as food. They need it to be broken down into nutrient-rich material by worms or microorganisms.

Worms of the deep

Deep burrowing worms are about the size of a pen. They are powerful burrowers, who make and maintain vertical burrows.

Worm plumbers

Undisturbed vertical burrows can last for 30 years. These are important channels, which allow water and air to move through the soil.

1 From tree to floor

In the autumn, many leaves burst into red, orange, and yellow colours. This means they're almost ready to drop from trees and shrubs. Soon, they will die and fall to the ground.

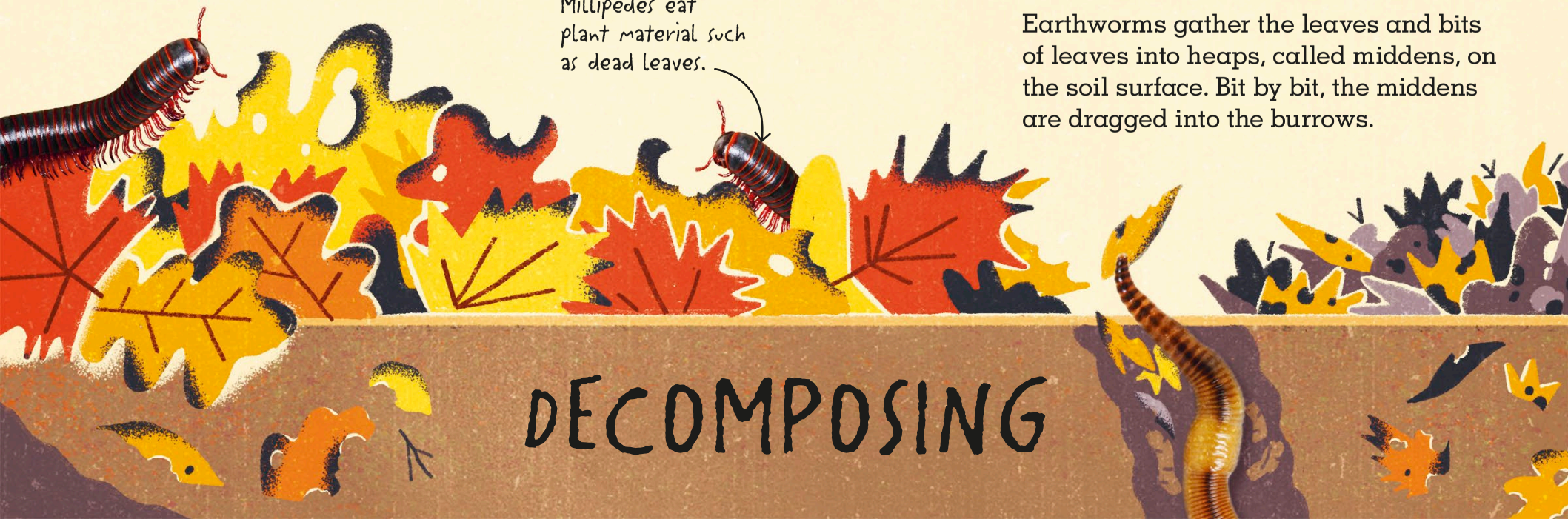
Trees that lose their leaves yearly are called deciduous.

2 Broken up

At night, soil-animals such as millipedes and earthworms shred the dead leaves into small pieces to eat. This also makes the leaves easier to eat for other soil-dwellers.

3 Down into the soil

Earthworms gather the leaves and bits of leaves into heaps, called middens, on the soil surface. Bit by bit, the middens are dragged into the burrows.



DECOMPOSING

Many soil organisms decompose (break down) plant matter. Living plants feed on the broken-down material, so dead things don't pile up on the ground!

What looks like white fur on a leaf is fungi.

4 Smaller and smaller

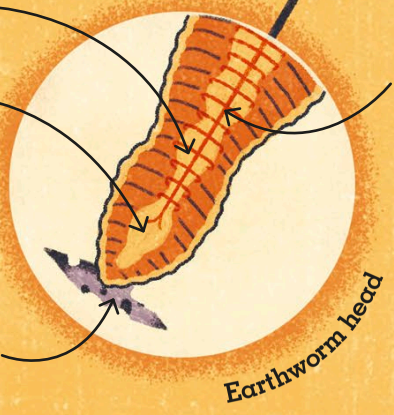
Microbes (tiny living things) such as fungi wrap around leaf fragments. Microbes release chemicals to decompose the fragments even further.

Decomposed plants keep soil fertile for things to grow.

Food is stored here for a short while.

Previously eaten stones help grind up food.

Powerful lips suck in food.



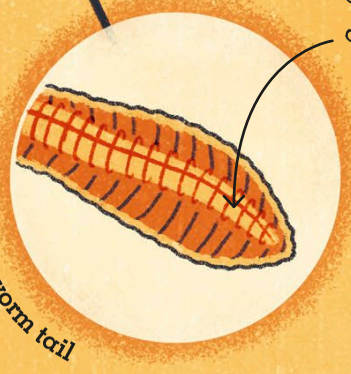
Earthworm head

Nutrients are taken in as the food passes through.

5 Worm poo

Decomposing leaves are eaten and digested by earthworms. Worm casts (poo) are mixed into the soil. Microorganisms such as bacteria feed on worm casts and release nutrients for plants.

Casts pass out the other end.



Earthworm tail

DRY SOIL

Dry desert soils are home to plants that can live without rain for long periods of time. Plants are few and far between, but they have amazing abilities to absorb water.

Cactus

A network of shallow, wide-spreading roots helps the plant drink as much water as possible if it rains.

Living stones

Pebble plants can absorb water from fog. During droughts they shrink below ground, so they need even less water.

Some cacti can last for two years without rain.

Saxaul tree

This tree's root networks hold large amounts of dry sand in place. Planting more of them stops soil blowing away.

SOGGY SOIL

Rainforests are home to thousands of plants, but the soil is shallow and poor. Up to 10 metres (400 in) of rain a year washes the nutrients away. Some clever plants live on each other, instead!

Rainforests get ten times as much rain as deserts.

Fig plants wrap around tree trunks.

Strangler Fig

This plant's seeds sprout in the moist, nutrient-rich tree tops. The seedlings grow down to the forest floor and eventually take root in the soil.

Animals eat fig fruits, and their poo spreads the seeds.

Fungi on the roots help the plant absorb nutrients.

Buttress roots

Tall trees have thick buttress roots that grow out from the trunk above ground for stability. Nutrients are near the soil surface, so tree roots are shallow.

BEAUTIFUL BOGLANDS

Squelchy, muddy peat bogs are found in wetland areas. They are home to some unique and beautiful plants. The soil, called peat, can preserve ancient objects and bodies.

How is peat made?

Boggy ground has little oxygen. Most microbes need this to decompose dead things. Most bogland is also too acidic for these microbes to live in. So dead plants build up in layers to form peat.

Deer grass

Common frog

Barrels of butter up to 2,000 years old are some of the strangest bog finds.

Ancient things

Some things last for thousands of years in bogs without breaking down. The bodies of ancient people, called bog bodies, have even been found!

Azure hawker dragonfly

Cross-leaved heath


Hen harrier
Global warming
Carbon dioxide (CO_2) is a gas that traps heat and makes the Earth warmer. Peat stores large amounts of carbon (found in CO_2), so protecting boglands could help to slow global warming.
Peat contains as much carbon as is found in the air.
Plenty of plants
Peat bogs are habitats for rare plants such as sphagnum moss. These tiny plants look like a multi-coloured carpet because they grow so close together.
Hare's tail cotton grass
Sphagnum moss
Peat is formed over many thousands of years.
Golden plover
In the past, many people dried and burned peat to heat cooking stoves.
Emperor dragonfly
Black soil
Peat is mostly made up of partly decomposed plants. This makes it black in colour. It feels soft and spongy to touch.

SUN, WIND, AND RAIN

Heavy rain might make us very wet, but it also washes away bare soil. Soils need plants to protect them from all kinds of weather, from splashy rains to burning sunshine and howling winds!


Weathered downstream
Soil taken away by weather is washed into rivers and carried out to sea. The soil that took thousands of years to form is lost forever.
It takes 500 years for 2.5 cm (1 in) of soil to form.
Snow can protect grass from freezing temperatures that might damage it.
Frozen solid
Farmers might leave fields unplanted over winter so that crop diseases go away. Cold weather can freeze bare soils in place to stop them being carried away by wind.

AWAKE AT NIGHT

The ground is alive with activity at night. Nocturnal animals sleep all day and awaken when you're in bed. They scurry around to find food in the moonlight.

Some animals can see in the dark.

Mice forage for meals of nuts and fruit.

Furtive Foragers

Small creatures often forage (search) for food, such as berries, at night. It is safer in the dark because it's harder for predators to see them.

Antlion larvae (young) dig pits that trap ants to eat.

Ground hunters

Ground hunters rest through the day in damp, dark places such as underneath rocks. They emerge at night to hunt nocturnal foragers.

Giant centipedes are deadly insect hunters.

Beetles hunt juicy caterpillars and grubs.

Flying Fiends

Many nocturnal birds are fierce hunters that swoop down to catch prey on the ground. The Australian owlet-nightjar catches crickets and ants that emerge after sunset.

Singing insects

High-pitched chirping sounds can fill the night. Insects such as crickets make the noise by rubbing body parts together, often to attract females.

Bull ants forage for food between dusk and dawn.

Night-blooming flowers

Some cacti only bloom at night. The flowers attract winged creatures that carry pollen to other flowers, which need the pollen to make seeds.

FUNGUS KINGDOM

A poisonous toadstool in the forest is just one bit of a fungus – as is a mushroom in your kitchen cupboard! Fungi can be vast soil organisms or tiny microbes, without which many plants couldn't grow.

What are fungi?

Fungi are not plants, animals, or bacteria. They have a stringy body made up of thousands of tiny threads that spread throughout the soil.

Plant pals

Fungi can live on plant roots. They take nutrients from the soil for the plant and receive food in return.

Fungal food

Fungi have no mouths or stomachs. They absorb their food directly, or release chemicals called enzymes that break it down so it can be absorbed.

Magical mushrooms

A mushroom is the part of a fungus that grows out of the soil to release spores. Wind carries the spores away, which grow into new mushrooms.

Humongous fungus

The largest organism on Earth is a fungus. It spreads out for 8.8 sq km (3.4 sq miles) beneath an entire forest in Oregon, USA.

WONDERFUL WORMS

They spend their lives hidden from sight, unless you know where to look. Lift the lid of a compost bin to find stripy tiger worms, dig a hole to see pink, green, and even yellow-tailed earthworms, and at the beach look out for wriggly piles of sand made by burrowing sandworms.

Sandworms

Sandworms live on the beach. They eat sand as they burrow and poo it out in loopy piles. Count the number of piles to guess how many sandworms there are.

Star-nosed mole

Tentacles around this mole's mouth can detect the electrical signals of nearby prey. The star-nosed mole is the fastest eating mammal on Earth!

MARVELLOUS MOLES

Beneath your feet a mole could be prowling through its dark network of underground tunnels. It spends most of its time digging and waiting for wormy prey to fall through the soily ceiling.

Eastern mole

This mole lives in North America. Like most moles, it has spade-like hands to help dig through the soil.

Eastern moles are nearly blind — they have no need to see underground.

Molehill

The soil dug out by moles as they burrow gets tossed into piles, called molehills.

Long-tailed weasels eat moles and can invade their tunnels.

Tunnels might be used by multiple moles over time, if the mole moves out!

Feeding tunnel

Mole tunnels are deadly traps for worms. The burrowing worms fall through from the soil above. This causes vibrations (ground movement) that the mole quickly moves towards.

Baby moles are hairless until the age of around two weeks.

Moles live on their own and fight off invaders.

Nest

This chamber is lined with soft piles of dried leaves and grass. Moles give birth and keeps their babies safe here.

Worm larder

A toxin in mole spit can paralyse worms. This means they are alive, but can't move. 'Larders' are made to store hundreds of paralysed worms.

Most moles are smaller than your foot!

BURROWERS

Have you ever seen a creature disappear into a hole? This could be the entrance to a network of tunnels and chambers, called burrows.

Stripy faced badgers eat rabbits.

Coyotes wait hungrily for gophers to pop up.

Gophers push soil up to the surface as they dig, which leaves long mounds on the surface.

Rabbit hole

European rabbits graze on plants above ground, at dusk and dawn. If a predator disturbs them, they dive into their tunnel network, which is called a warren.

Gopher town

American pocket gophers use their claws and huge teeth to dig tunnels. They pop out of holes to eat plants. Their burrows include deep nests and food-storage chambers.

Aardvark park

African aardvarks live in their cool, underground burrows during the hot day. They forage at night for termites, using their long tongue to lap up insects.

Chipmunk county

There's no mound of dirt by the entrance of a chipmunk burrow because they carry away the dug-up dirt in their cheeks. The burrows have many entrances and chambers of nuts and seeds.

Instead of pee, woodlice release a gas from their shells.

Woodlice

Cheesy bug and butchy boy are alternative names for woodlice. They are crustaceans, like shellfish.

Woodlice like to nibble rotting wood and leaves.

Woodlice roll into a ball for protection from predators.

Insects

Insects have six legs and their bodies are divided into three parts. Many insects live underground. Bumblebees sleep in soil over winter.

Some cicadas spend their first 17 years below ground.

Spiders

Spiders have eight scuttling legs. They range from pinhead-sized to ones that are bigger than your hand! Spiders make sticky webs to catch prey such as insects.

Prey step on the webbed tunnels of some spiders. The web vibrates so the spider knows they are there.

Slug

SPINELESS INVERTEBRATES

Animals without backbones make up 90 per cent of all creatures on Earth. These are called invertebrates, and the ground is crawling with them.

Velvet worms shoot slime at prey that hardens to stop them escaping.

Molluscs

Molluscs move around on a large, slimy foot. Most molluscs have shells. Snails have shells that they live in. They use their shell to hide from predators.

Snail

Velvet worms

The soft texture of these creepy-crawlies gives them their name. They look like worms but have lots of legs.

Each leg has a tiny pair of claws.

Forager ants find leaves for the colony.

Leafcutter ants

These ants gather leaves to feed fungi, which they grow for food. The ants do different jobs to keep the colony going.

Ant nations

Imagine you were small enough to follow an ant underground. You'd find yourself in a connected set of tunnels teeming with hundreds, thousands, or even millions more ants. This is called a colony.

Ant tunnels are like roads in human cities.

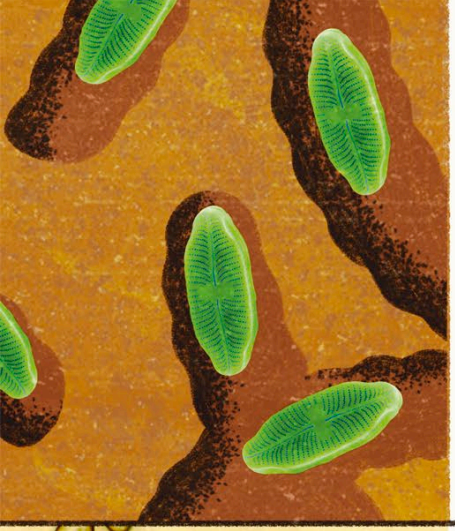
Usually, one queen lays every egg in the colony.

Super-colonies

Colonies can join up to form super-colonies. One European super-colony stretches for 5,955 km (3,700 miles).

Excavators dig new tunnels and carry away the dirt.


Soldier ants will bite attackers to defend the colony.
Phorid flies lay eggs inside some ants.
When finding leaves, a scent is left for others to follow.
Fungus garden
Leafcutter ants chew the leaves into a pulp, which they feed to the fungus.
Gardener ants look after the fungus.
Waste, such as dead ants, is taken to the dump by waste-handlers.
The fungus eats the leaves to grow.
Queen ants can lay up to 200 million eggs. These turn into maggot-like larvae.
Larvae turn into hard pupae, which become ants.
Nurse ants care for the eggs, larvae, and pupae.
Dumps can spread diseases.
Rubbish dump
Waste is stored in special chambers. It is then carried out and dumped a safe distance away from the nest.
Old food and dead ants can lead to disease.



Single cells

Living things are made up of miniscule parts called cells. You contain trillions of them! However, most microbes are 'single celled' — the whole creature is made of just one cell.

Trouble makers

Some soil microbes make plants ill. Raindrops can splash off soil, picking up and carrying these microbes to the leaves of plants above. Little plants on the ground can stop this from happening by catching the raindrops before they splash on the soil.

Hidden heroes

Microbes can do good things for plants. Some protect the roots of plants by releasing chemicals called antibiotics. These kill other microbes that can harm plants and improve the plant's ability to fight off disease. On top of that, some of them glow in the dark!

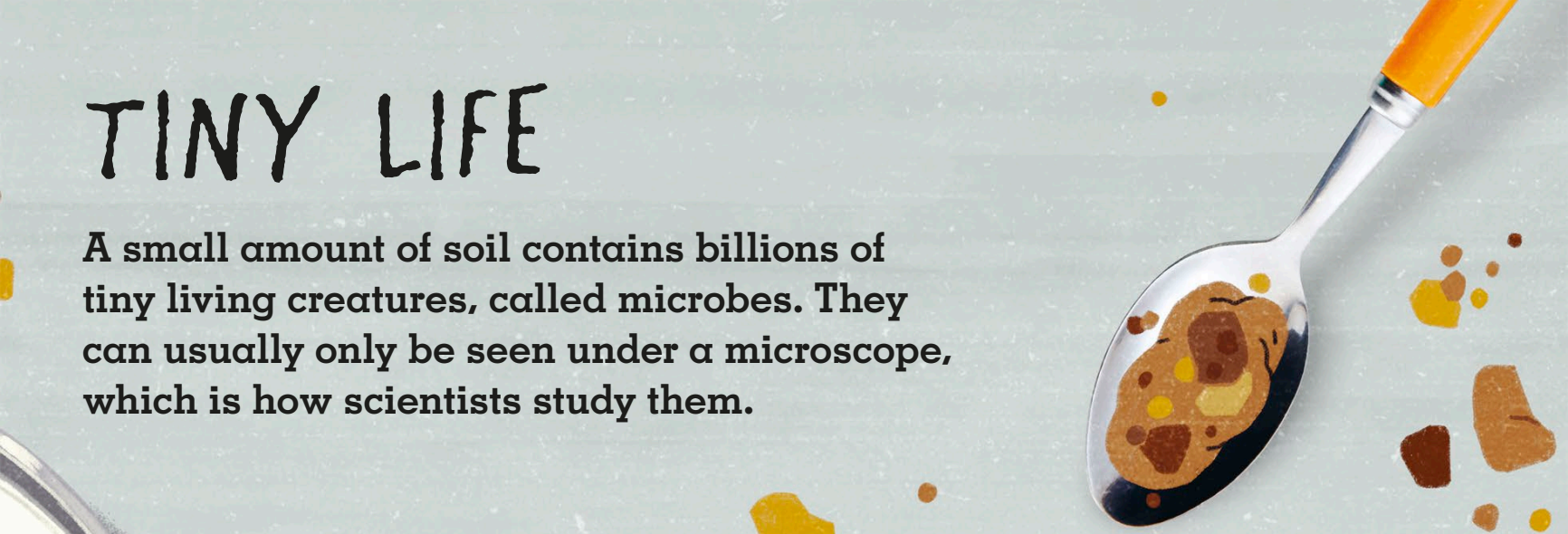
Soil spaces

Microbes help to keep a good structure in soil. They create tunnels and caverns, and make a special glue that keeps the spaces open. Water and air, which plants need to stay alive, move through these spaces.

You don't need a microscope to see large clumps of white, fluffy fungi. Underground, fungi make sticky substances that help stop tiny spaces from collapsing. These spaces keep water and air in the soil.

TINY LIFE

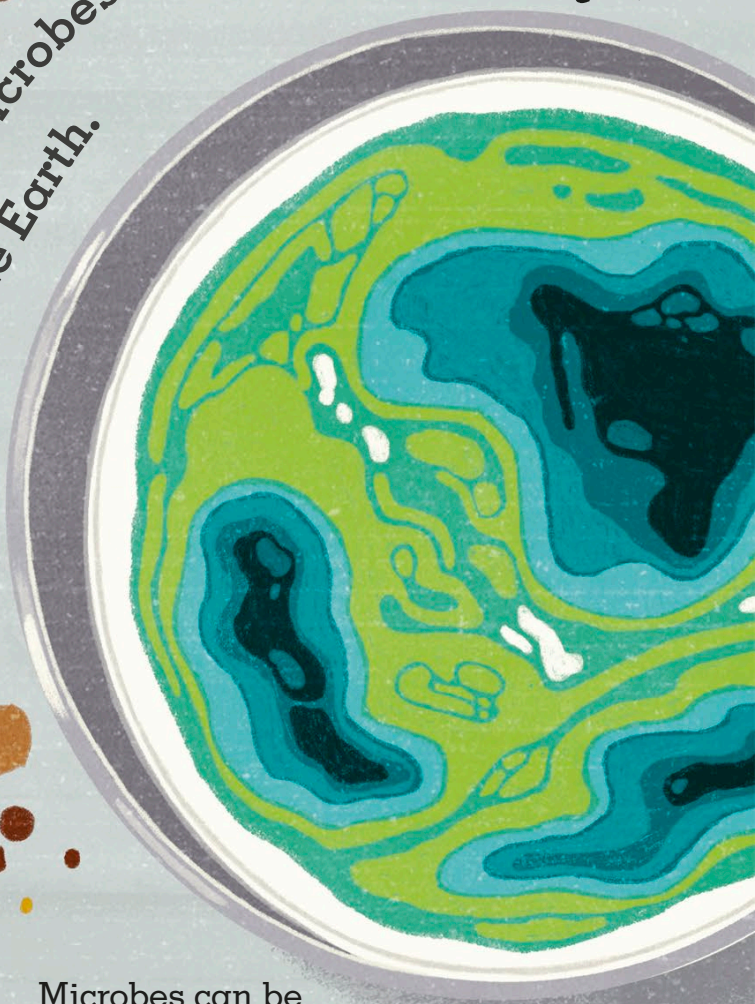
A small amount of soil contains billions of tiny living creatures, called microbes. They can usually only be seen under a microscope, which is how scientists study them.



The trillions of microbes found in soil don't just sit around – they do lots of useful jobs. For example, some change nutrients into forms that plants can absorb as food. This means that the plants grow big enough for us to eat ourselves!

A teaspoon of soil contains more microbes than there are humans on the Earth.

Algae

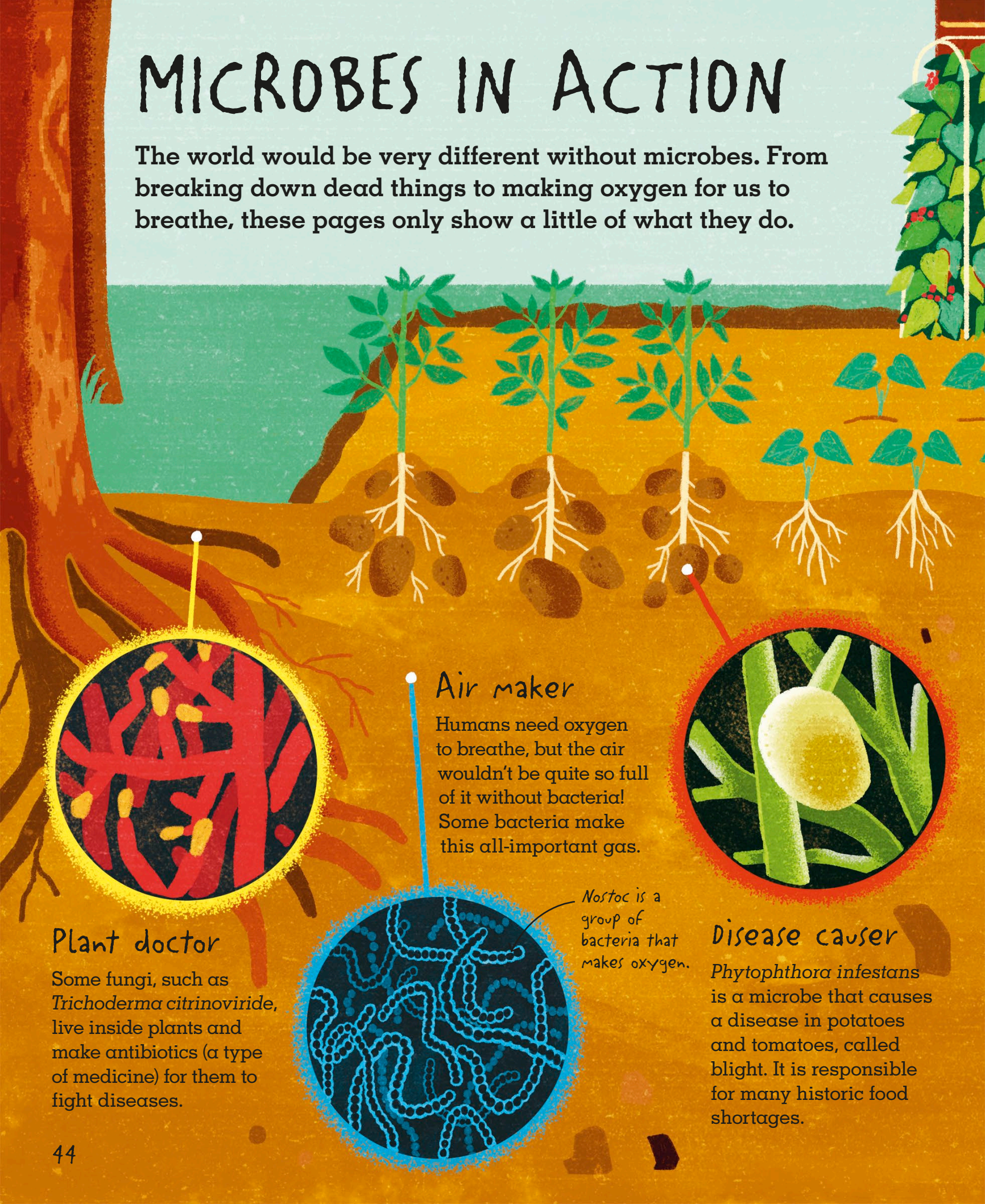


Fungi

Microbes can be seen in large numbers as blue and green slimes on the surface of soil. These can be microscopic plants (algae), bacteria, or mixtures of both.

MICROBES IN ACTION

The world would be very different without microbes. From breaking down dead things to making oxygen for us to breathe, these pages only show a little of what they do.



Plant doctor

Some fungi, such as *Trichoderma citrinoviride*, live inside plants and make antibiotics (a type of medicine) for them to fight diseases.

Air maker

Humans need oxygen to breathe, but the air wouldn't be quite so full of it without bacteria! Some bacteria make this all-important gas.

Nostoc is a group of bacteria that makes oxygen.

Disease causer

Phytophthora infestans is a microbe that causes a disease in potatoes and tomatoes, called blight. It is responsible for many historic food shortages.

Food Fixer

Some plants would find it tricky to survive without bacteria such as *rhizobia*. This type of microbe takes a gas called nitrogen from the air and uses it to make plant food.

Eco-warrior

Methane is a greenhouse gas that causes global warming. *Methylocapsa gorgona* takes methane out of the air, because it needs the gas to survive.

Transformer

Fungi such as *Mortierella* break down dead plants and animals into new material. Other living things can then eat the broken-down material.

ALL THAT GLITTERS

If you dig a hole you'll probably hit a stone, and rubbing soil between your fingers will reveal a grainy texture. Rocks and minerals have been transformed into small pieces in soil over thousands of years.

Rain freezes in cracks and expands to break bits off the rock.

Rocks to pebbles

Rocks are crumbled and dissolved by rain and ice. This process is called weathering. The particles eventually become small enough to form part of soil.

Panning for stones

Precious stones are heavier than soil. They can be found by panning, or washing the soil off with water.

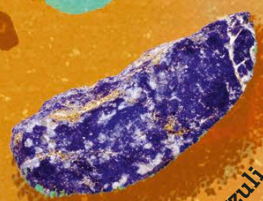
Stones can be transported away from where they formed by rivers.

Solid treasure

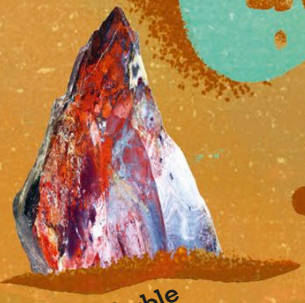
Stones can be rocks or minerals – the hard substances that rocks are made of. Rocks form in different ways. Some cool from lava spat out by volcanoes!

Dalmation stone

Rose quartz



Lapis lazuli



Marble

Clay particles look like tiny, flat plates.

Clay

Sand

Silt

Sand particles look like very small rock pieces.

Sizing it up

Soil particles come in different sizes. Imagine a clay particle as a large coin. Next to it, silt would be as big as a tennis ball, and coarse sand the size of a hot-air balloon!

Gold

Garnet

Sandstone

Citrine

The best soil for plants has not too much sand or clay.

Plant Food

Soil is made up of sand, silt, and clay particles. The amount of each affects how fertile soil is, how much water it holds, and how well water drains through it.

Both plants and animals can become fossils.

Fossils are the traces (such as footprints) or remains in rocks of living things from millions of years ago.

It can take eight years for soil as thick as card to form.

Wetland soils

Peat soils in wetlands aren't just home to unique species of plant. They store more carbon than any other soil. If this is released into the air as a gas, it traps heat and can speed up global warming.

There are more than 70,000 types of soil in the USA alone.

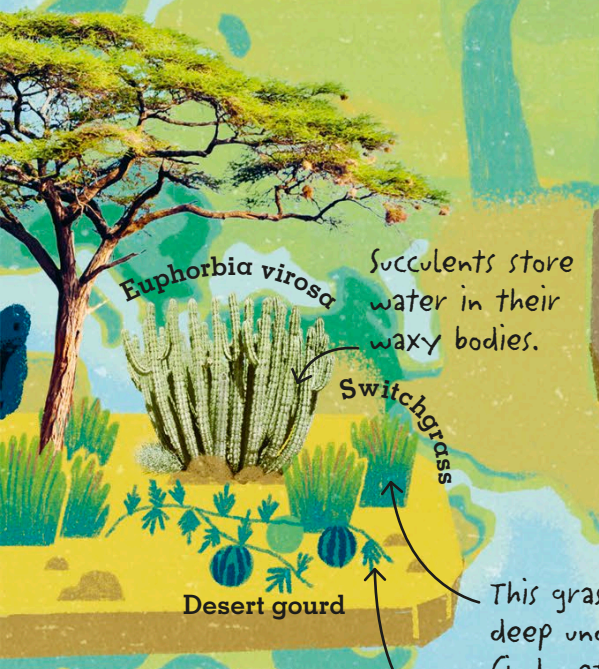
GROUND AROUND THE WORLD

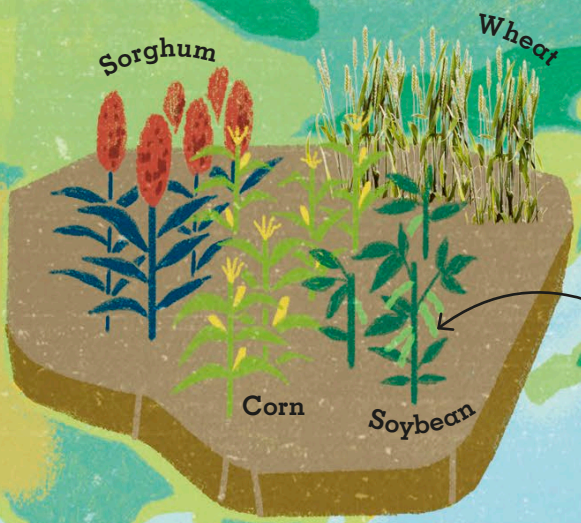
A single country can contain thousands of different soils. Plants suited to each soil range from tall trees that look like they have legs (the walking palm) to squat succulents.

Rainforest soils

These are found in warm regions with plenty of rainfall. The soil has few nutrients, but millions of plant species are found there.

Plants make up 90 per cent of the world's food.





Farmland soils

Soils with lots of nutrients are used across the planet to grow important crops such as wheat. China is the world's biggest producer of food crops.

Dryland soils

Dry soils are found in areas with low rainfall. Plants here have long roots and thick, fleshy stems to save water. The roots are important for holding the soil in place.

Plants can't grow in most of the frozen land of Antarctica.

Half of our rainforests have been chopped down in the last century.

Overgrazing

The main cause of desertification is overgrazing. Too many animals grazing and trampling on plants can lead to soils becoming bare. The wind then blows or the rain washes the bare soil away.

Deforestation

Trees are chopped down for fuel, to make things with, and to clear land for farming. If too many trees are chopped down without new ones being planted, this leaves bare soil with no tree roots to hold the soil in place.

Wood is used to make paper.

Loose soil can be washed or blown away.

Only a few types of plants can grow in desertified land.

SOIL TO SAND

People's actions are causing healthy soil to lose its nutrients and turn into loose, dry sand. This process is called desertification. It is bad news for us and for the environment.

Dry land has few plants, which many animals need to feed on.

Over-farming

Too many crops take nutrients and water out of the soil. This means new plants are not able to survive in the soil.

Areas around today's deserts are most at risk of desertification.

Rain doesn't fall during a drought, which affects plants.

Global warming

A hotter planet could cause desertification in lots of ways. For example, some crops don't grow as well in hotter weather. Less rainfall also leads to dry soil that blows away.

Desertified soil is too loose for plants to anchor their roots in properly.

Over 100 countries are at risk of desertification.

Desertified land

Few things grow in sand. It also holds less carbon than fertile soil. If carbon is released into the air as a gas, it traps heat and can speed up global warming.

Zai pits

Tackling the problem

People are looking at ways of using desertified land. In some areas, plants can be grown in holes called zai pits. These collect water and can be filled with nutrient-rich animal poo or soil.

MOON DUST

The Moon is silvery grey, without the Earth's green patches of plant life. There is no liquid water, or atmosphere (gas layer) to block out harmful radiation and provide the gases a plant needs to survive. However, Moon dust is similar to soil.

Moon dust

There are no living things to create tiny tunnels and caverns in Moon dust. On Earth, water, nutrients, and gases move through these spaces for plants to absorb.

Moon dust is mainly tiny bits of glass.

Craters are formed when large meteors hit the Moon.

Moon rock forms from lava cooling on the surface.

True soil

Soil needs living things. These eventually form the organic matter inside it, as well as its structure. Even if you added water to Moon dust, it would just form a paste.

Explosive formation

Moon dust is formed mainly by grinding and explosions, caused by meteors. The impact breaks the rocky surface into pieces.

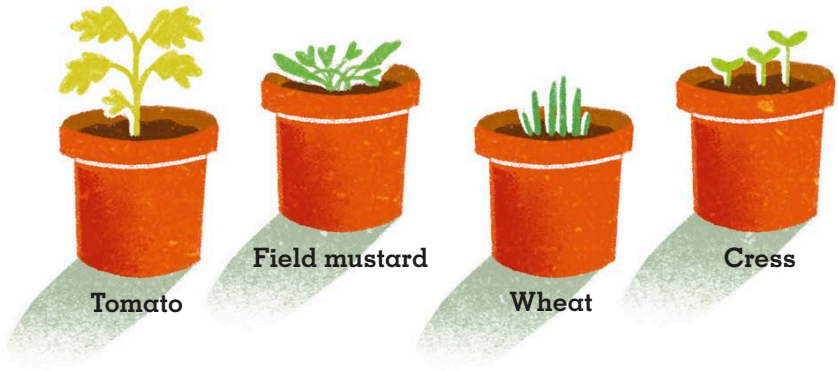
Studying lunar soil

People last went to the Moon on the Apollo missions of the 1960s and 1970s. Astronauts collected Moon dust to study back on Earth.

Astronauts tried tasting Moon dust!

Plants in lunar soil

Moon dust contains many of the nutrients in soil. Scientists have even been able to grow plants in soil that mimics Moon dust. The plants grew for up to 50 days.

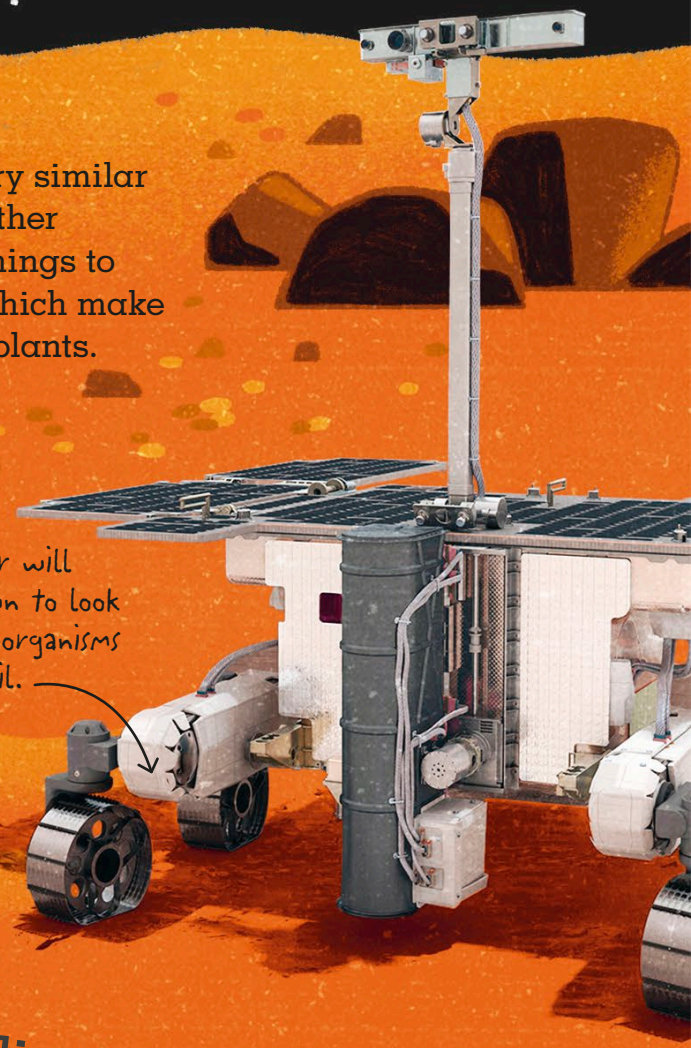


CAN PLANTS GROW ON MARS?

Humans may one day garden on Mars. The soil has the nutrients needed by plants, with toxins that could be removed. However, Mars has no liquid water, so this would need to be produced for the plants. The plants would also need protecting from harmful conditions.

Sort-of soil

Martian soil is very similar to moon dust. Neither contains living things to create spaces, which make soil suitable for plants.



The rover will drill down to look for microorganisms in the soil.

Martian rocks

Long ago it rained on Mars. The water froze in cracks on the rocky surface. The ice expanded and broke off tiny fragments of rock. These are still part of the soil today.

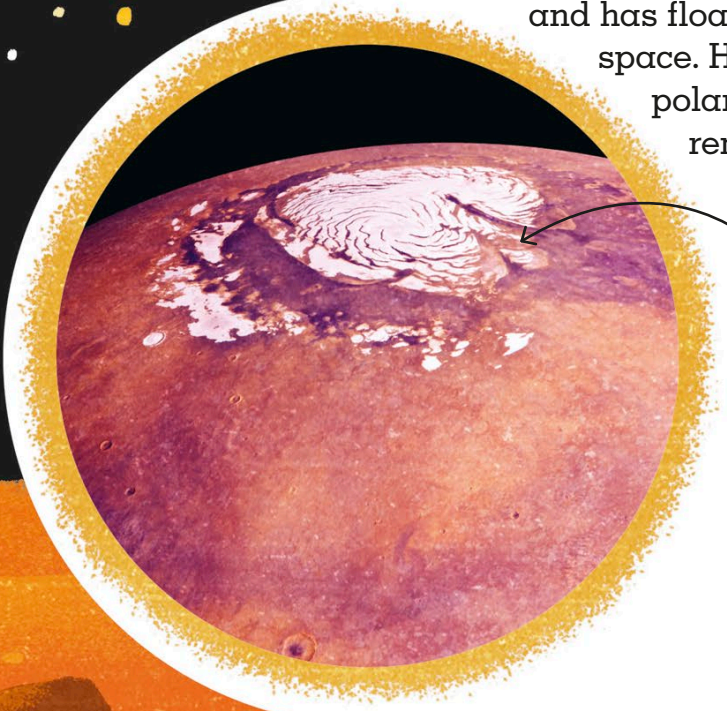
Mars's atmosphere is 95 per cent carbon dioxide (a gas plants need).

The atmosphere

The layer of gas around a planet is called its atmosphere. Mars's thin atmosphere doesn't filter out harmful radiation from the Sun, such as solar wind (particles that can damage anything they touch).

Water on Mars

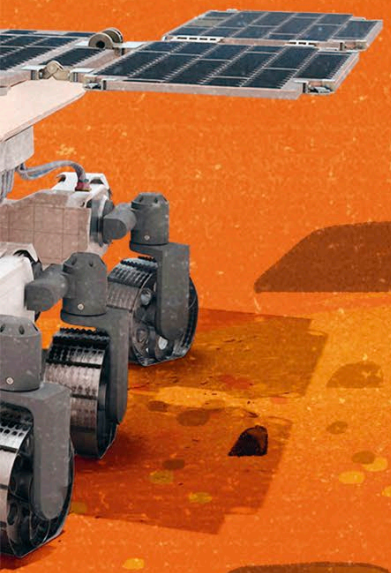
Mars's water has mostly been heated into a gas by the Sun, and has floated off into space. However, polar ice caps remain.



The ice caps get so cold that gas freezes solid and falls from the air.

Investigating Mars

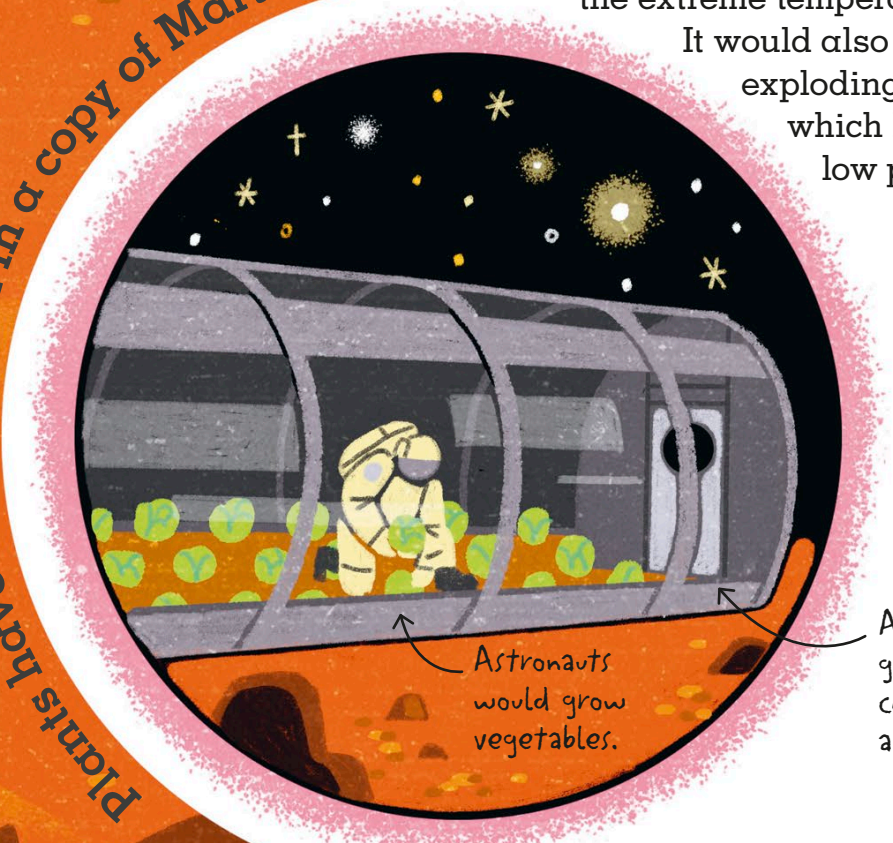
In 2020, The European Space Agency plans to send a rover to Mars. Its mission is to search for alien life that could be buried in the soil.



Plants have been grown in a copy of Martian soil.

Astro-gardeners

To grow plants on Mars, a special greenhouse would be needed to protect the plants from the extreme temperatures. It would also stop them exploding in the air, which has very low pressure.



Astronauts would grow vegetables.

A special greenhouse could add air pressure.

BE A SOIL SCIENTIST

Microbe meal

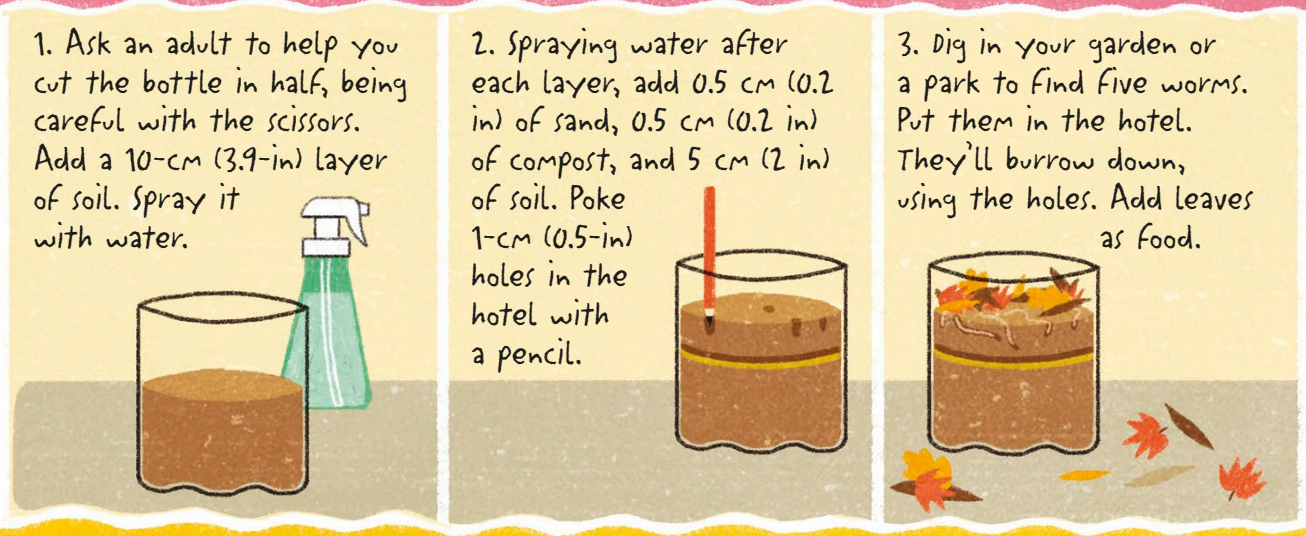
You will need: a trowel, card, a shovel, a pen, tape, a stick, and an old

Healthy soils are home to organisms, from earthworms to tiny microbes. If you've got a garden, bury a cotton sock to find out if the soil is full of hungry things. Make sure the sock is 100% cotton!

Worm hotel

You will need: a 2-litre disposable plastic bottle, scissors, garden compost,

Earthworms spend their lives hidden from view. Build them a worm hotel to discover what they do in the soil, before returning them to the soil to carry on the good work.



Perfectly Wonky carrots

You will need: a patch of soil for growing, a trowel,

Stones and twigs are often removed from the soil before carrots are grown. This is so they grow straight down without objects blocking their way. See what happens otherwise...

Health and saftey

If you have a cut or graze, cover it with a plaster before touching soil. After you've touched soil, wash your hands!

Hints and tips

- Don't use worms from a compost heap. These don't live in soil.
- Look after the worms by keeping them in dark, cool, and damp conditions. Carry them to and from the wormery in a tub lined with damp kitchen towel.

100%-cotton sock.

4. Tape card to a stick to make a marker. Mark the spot.

5. Dig the sock up after eight weeks. If it's been eaten, with plenty of holes, the soil is healthy because it has lots of organisms!

soil, sand, a pencil, a spray bottle, cardboard, leaves, and tape.

4. Worms like the dark! Wrap cardboard around the wormery to block out light. Spray the hotel with water daily.

5. After a week, see how the worms have changed the soil. There will be lots of burrows, the layers will have begun to disappear, and the leaves may have been dragged into the soil.

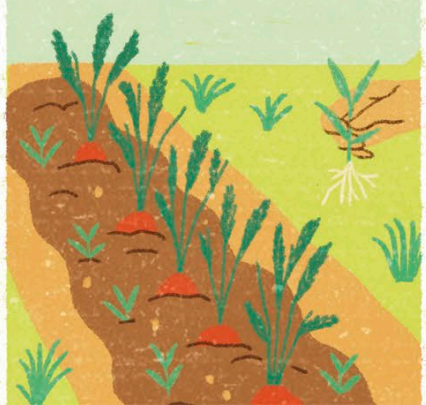
6. Release the worms back into their original home after your week's experiment.

a watering can, a rake, carrot seeds, newspaper, plant labels, and a shop-bought carrot.

4. Water the carrots often but gently, at ground level.

5. When the plants are around 10 cm (4 in) tall, thin them to one plant every 6 cm (2 in) by pulling out the smaller ones.

6. After 16—20 weeks your carrots should be fully grown! Gently pull them out of the ground.



7. Compare the carrots to a shop-bought one to see the difference!

LOOKING AFTER SOIL

To keep colour-speckled insects and plenty of plants all around, we need to make sure we look after the ground. We can do small things with big impacts.

Keep to the path

Plant roots hold soil in place so it doesn't get worn away by wind, rain, or feet. If the plants around a path are trampled and killed, it may get wider and wider as the soil disappears. In parks, make sure to keep to the path.

It takes around three to nine months to make compost.

Make compost

Fruit and vegetable waste breaks down into brown, crumbly compost. This can be mixed into the soil to help plants grow. Find out if special food-waste bins and collections exist in your neighbourhood. If you have a garden, make your own compost heap!

Wildlife feed on fungi growing on different types of wood.

Make tiny animal shelters

Find a shady spot in a park or your garden and make a pile of logs and twigs. Try to use as many different types of wood as possible. This makes an excellent shelter for beetles, centipedes, and spiders.

Leave soil alone

Digging disturbs soil animals. If you have a garden, pick an unused patch and let nature go wild! You can sprinkle native wildflower seeds here to help attract bees and butterflies. Ask permission first.

GLOSSARY

Bacteria
Type of microorganism

Burrow
Tunnel made by a creature, often to find food or for shelter

Carbon
Substance found in all living things and in the gas carbon dioxide

Carbon dioxide
Gas found in the air, also written as CO_2

Cast
Poo of a worm

Decomposition
Process of living things breaking down into their chemical building blocks after death

Deforestation
Process of the trees in a forest being chopped or burned down

Desertification
Process of fertile soil becoming dry, loose sand

Ecosystem
Community of plants and animals in a single area

Fertile
Suitable for things to grow

Flower
Part of a flowering plant that makes seeds

Fungi
Group of living things separate to plants, animals, and bacteria

Gas
Substance that can be found in the air, with no shape

Global warming
Process of the Earth becoming warmer

Insect
Small creature with six legs and a body with three parts

Invertebrate
Animal without a backbone

Larva
Newly hatched insect

Leaf
Part of a plant that turns nutrients, carbon dioxide, and oxygen into food for the plant

Microbe
Another name for a microorganism

Microorganism
Tiny living thing that can usually only be seen with a microscope

Mineral
Natural material that can be found in rocks

Network
Group of joined-up things, such as tunnels

Nutrient
Substance that a living thing uses to grow

Organic
Living or once living, and containing carbon

Organism
Living thing, such as a microbe, plant, or animal

Particle
Tiny piece of something

Pollutant
Substance that enters water or air and makes it unsafe

Predator
Animal that eats other animals

Prey
Animal eaten by another animal

Pupa
Early stage of life for some insects in which they grow a hard case and don't move around

Radiation
Particles or rays of energy that can be harmful

Root
Part of a plant that takes in nutrients and water

Sediment
Bits that settle at the bottom of a body of water, such as a lake

Spore
Part of a fungus that could grow into a new fungus

Stem
Part of a plant that holds up the flowers and leaves

Topsoil
Top layer of soil, which contains lots of organic matter

INDEX

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