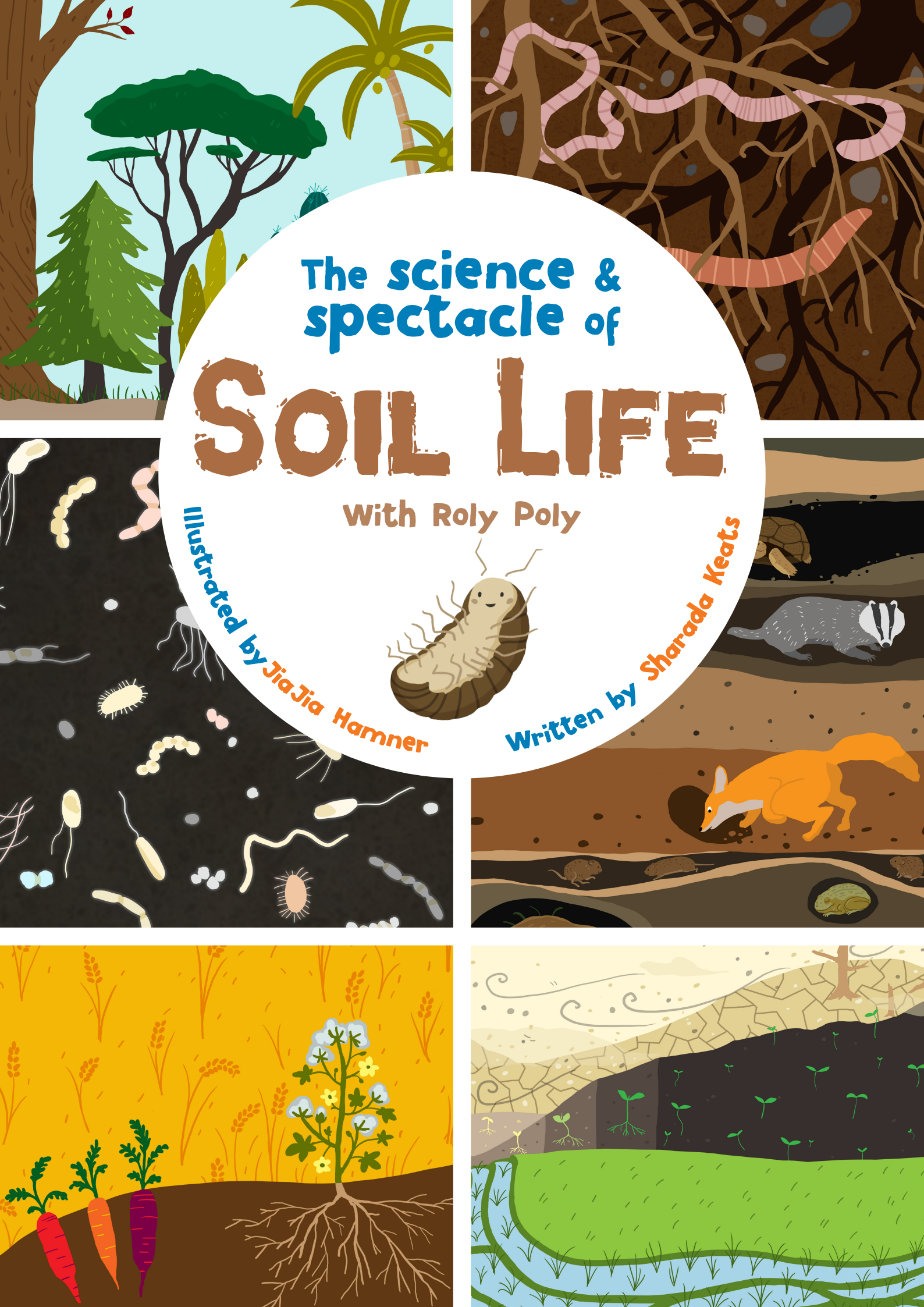

The science & spectacle of
SOIL LIFE
With Roly Poly
Illustrated by JiaJia Hamner
Written by Sharada Keats

Contents

The Earth Beneath

Soil is alive and soil is life. Human life and life on Earth as we know it depends on soil.

Most land on Earth is covered by soil. Many ingredients make up soil, including nutrients that plants and people need to thrive. And soil is absolutely full of life. Scientists have only catalogued a fraction of these soil-dwelling lifeforms. Most are so small, we call them **microbes**.

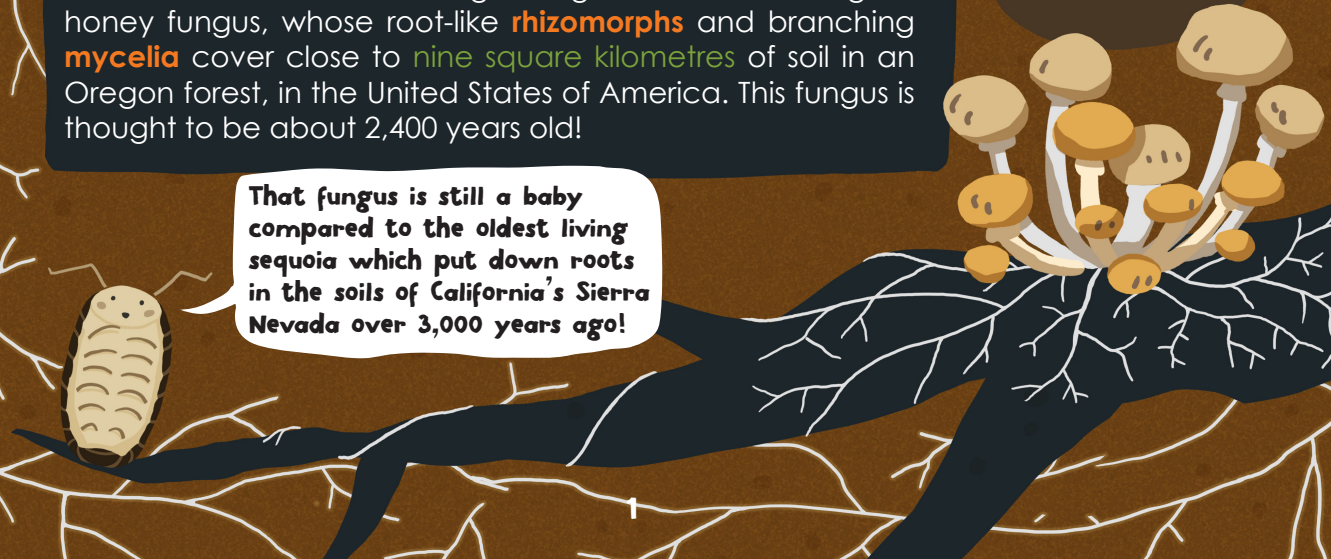
Soil ingredients

Different combinations of these ingredients make different types of soil.

It's ALiiiiiive

You might think the largest living thing on Earth is a majestic tree like the giant sequoia, or perhaps a massive blue whale… but scientists believe the largest organism is a humongous honey fungus, whose root-like **rhizomorphs** and branching **mycelia** cover close to nine square kilometres of soil in an Oregon forest, in the United States of America. This fungus is thought to be about 2,400 years old!

Did you know?
Mushrooms are the fruits of the much larger fungus living underground.



A Web of Life

Soil provides a rich habitat for a wide range of life – in fact it's the most **biologically diverse** part of our planet. Hundreds of thousands of plant species live in and around soil in all sorts of climates – from towering rainforest trees to desert cacti.

Underground, life ranges from tiny creatures invisible to the naked eye, like **bacteria**, **protists**, **nematodes**, and **tardigrades**, to slightly larger creatures like mites and springtails, to minibeasts like earthworms, ants, and termites. Larger animals all over the world, including mammals, reptiles, and birds also live in and around soil.

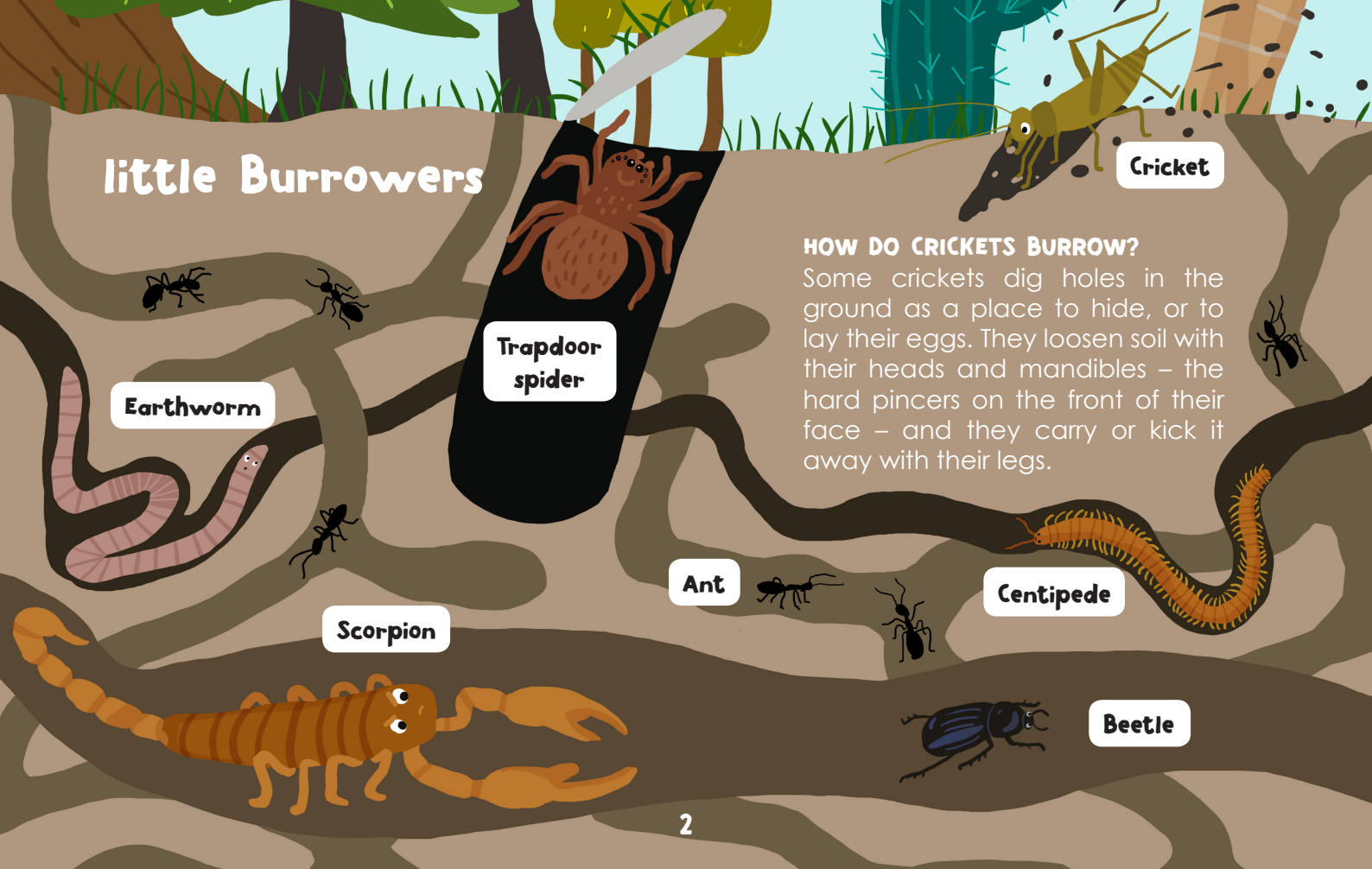

Nematodes


Tardigrades


Bacteria


Springtails

Little Burrowers



How do crickets burrow?

Some crickets dig holes in the ground as a place to hide, or to lay their eggs. They loosen soil with their heads and mandibles – the hard pincers on the front of their face – and they carry or kick it away with their legs.

BIG burrowers

Puffin

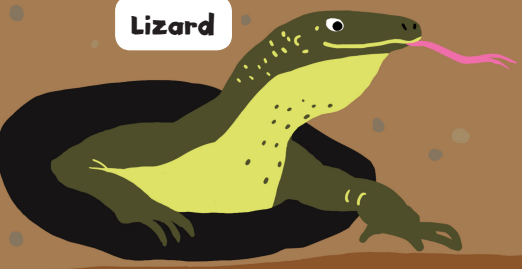
WHY BURROW?
Tortoises burrow for shelter, to **hibernate** and to nest!

Tortoise

Rabbit

Badger

Lizard



DID YOU KNOW?
Yellow-spotted monitor lizards are the only reptiles known to dig burrows in a spiral shape! They can be over 3 metres deep – the deepest nests dug by any known **vertebrate**.

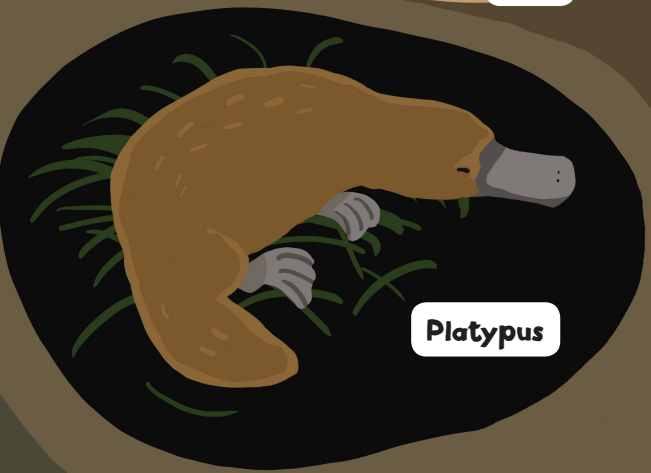
Do you know of any other animals, big or small, that burrow in the soil?

Fox

Vole

Burrowing frog

DROUGHT DODGERS!
Some frogs wait out dry periods by 'sleeping' underground until rains arrive – some can wait for years!



Platypus

Burrowing owl

The Underworld

Soil is life... but death and decay are serious business for many of soil's little creatures, reliant on soil's organic matter.

Organic matter at its least decomposed, like newly-dead plants and animals, is called 'raw organic matter'.

Bacteria and fungi eat raw organic matter.

Worms and insects can also eat raw or partly decayed organic matter.

The partly decayed organic matter is called compost, and contains living **saprotrophs**.

When the nutrients from dead things return to the soil, plants absorb them, continuing the cycle of life.

Humus is the most decomposed state of organic matter. Humus can gradually decay over several years, or it can remain for thousands of years. It helps soils to hold water, making them more drought-resistant.

Soil is full of dead and decaying matter. Most living things in soils, including plants, animals, fungi and bacteria depend on organic matter as a source of nutrients and energy. It also helps to make soils fluffier, allowing space for air and water. Darker coloured soils contain more organic matter than lighter coloured soils.

You might not find soil very delicious, but soil can be good for your human **microbiome** – the microbes in and on you!

You're not alone! Plant roots provide nutrients that little creatures crave. More than a habitat, roots also ooze fluids full of acids, sugars and other things that **microorganisms** like bacteria and fungi find delicious!

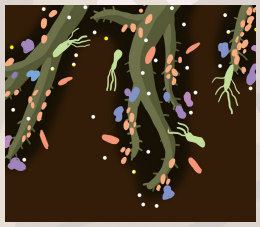
ROLY RECYCLES!

Creatures like Roly are expert recyclers, helping to release nutrients back into the food chain.

EARTH MOVERS and EARTH STABILIZERS

Earthworms help aerate and release nutrients into the soil, while plant roots help keep soil, along with nutrients, from being blown or washed away.

The longest individual earthworm ever recorded was discovered in South Africa in 1967, measuring 6.7 metres long. That's about 27 uncooked spaghetti noodles placed end to end!



THE UNIQUE ENVIRONMENT OF ROOTS

The **rhizosphere** is the name given to the area around a plant's roots, where the chemical and physical properties of the soil are influenced by the roots, and all the life living there.

The largest species of earthworm lives in Australia. It's called the giant Gippsland earthworm. It measures about two centimetres in diameter, and can grow to three metres long.

PUTTING DOWN ROOTS

One of the deepest root systems was found to belong to a shepherd tree growing in the central Kalahari, Botswana. These astonishing roots reached a depth of *68 metres*. They were discovered by people drilling wells to reach **groundwater** in 1974.

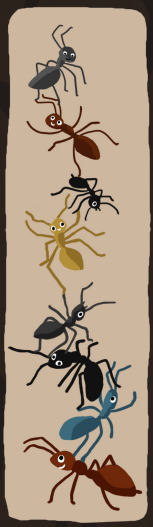
68 m is about the same as 12 giraffes standing on top of each other!

AMAZING ANTS

Every landmass on Earth, except Antarctica and a few remote islands, is home to ants.

Earthworms get a lot of credit for keeping soil healthy – and they do – but ants also play a vital role. Their tunnelling helps to turn over soil, allowing water and oxygen to reach the rhizosphere, so they are especially important to people who farm in dryland areas where earthworms are less abundant. Ants also disperse seeds, contribute to the breakdown of organic matter, and protect crops and gardens from pest insects.

Out of an estimated 22,000 species of ants, more than 12,000 have been catalogued. They range in size from around two millimetres long, to as long as four centimetres.



What Does Soil Do?

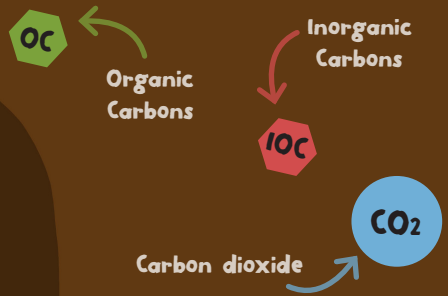
What did dirt ever do for me?

Soil gives us food! As much as 95% of our food comes from soil, or feeds on plants that do. Farms, gardens, orchards, and pastures rely on soil. The biodiversity of that soil is vital for its health and ours.

It also gives us fibre and fuel! Crops like cotton for instance, used to make our clothes, are grown in the soil.

It purifies water and reduces contamination. When water trickles through soil, it is cleaned by physical, chemical, and biological processes.

It helps to regulate the climate. Our planet is warming, and well-managed soils can play an important role in mitigating this, by storing carbon and decreasing greenhouse gas emissions.



It's a home! More than a quarter of all species on earth are estimated to spend at least some of their life in soil.

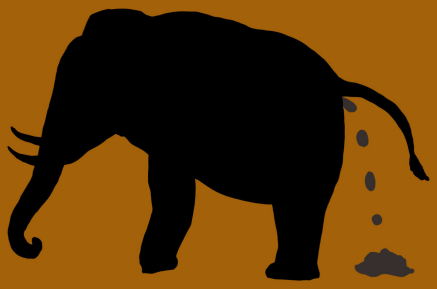
DID YOU KNOW?

Healthy populations of insectivorous animals can help soil capture more carbon. Leaf-eating insects, such as beetles, flies, and ants, release carbon dioxide into the atmosphere. In ecosystems where salamanders eat these insects, more leaves can turn into humus. This means the soil is able to store more carbon, which is good for the planet.

Soil is a place where nutrients are recycled. It stores and releases nutrients back into the food chain.

DID YOU KNOW?

Some kinds of animal manure – or poo – can be great for adding organic matter and nutrients to soil. Poo also attracts insects and the creatures who snack on them. Generations of farmers have used elephant dung, for instance, as a fantabulous fertilizer!



Soils soak up rainwater. They play an important role in helping to stop rivers from flooding.

We build *on* soil. We also build *with* soil. It provides a foundation for our houses, roads, railways and more. Soil isn't just a construction material for termites!

Soil can hold important pieces of our cultural history. It acts as a time capsule, preserving long-lost items that tell us about the lives of the people who lived a long time ago.

Soil can hold scientific treasures – bacteria for instance that might be used to make medicines, or for other scientific advancements.

More biodiverse soils generally mean more fertile fields and farms, and a more secure food supply.

But soil, and the life it sustains, is under threat.

What Can We Do For Soil?

Many human activities, like certain farming and construction practices, as well as deforestation and pollution threaten our soils.

Soils that have been **degraded**, lost or polluted can be renewed and replenished, with time and effort. We can tackle runoff, **erosion**, **salinization**, and **desertification**, add nutrients back into soils and do other things to improve soil health.

It's much more difficult to revive degraded soil than to just look after it in the first place.

The plants we harvest take out nutrients from the soil. How good a soil is impacts how nutritious our food is – and how much of it we can produce. To ensure sustainable food systems, we must take care to protect and conserve our precious soil. Agricultural terraces found around the world are an example of farming which can be better for our soils, though clearing native forests just to make farming terraces can be extremely damaging.

Soil is precious!

The soil nourishes us, and so much more. It deserves protection and respect, not neglect, over-use, and poor treatment.

VITAL VERTEBRATES

Vertebrates like hedgehogs, moles, lizards, and frogs enrich our environments and our lives. Their presence is an indicator of soil heath because they feed on the worms and insects living in happy soils.

Hedgehogs live in Africa, Asia, Europe and the Middle East. In some areas, their populations are in decline, owing to human activities. We can help by providing hedgehogs, and other vital vertebrates, with shelters, pesticide-free wild spaces and corridors.

Do you have a garden at home or at school? Perhaps there's a little patch of soil somewhere for you to experiment with growing vegetables or fruits?

Try using more **organic fertilizers, compost, and green manure** as a substitute for chemical fertilisers. This can be great for creatures living in soil, helping to build soil health and reducing reliance on chemical fertilizer.

Here's some things I recommend

Rotate your crops! Don't grow the same thing in the same soil season after season. Different crops need different nutrients. Some crops – like **leguminous** plants such as peas and beans – even help to add nutrients back into soils.

Don't over-water your plants! If the soil's too wet, the roots and the creatures living in the rhizosphere won't get the oxygen they need to thrive.

To avoid damaging fungi and killing earthworms, **don't turn the soil over too often** once you've planted. You can also put compost on top of the soil, rather than digging it in.

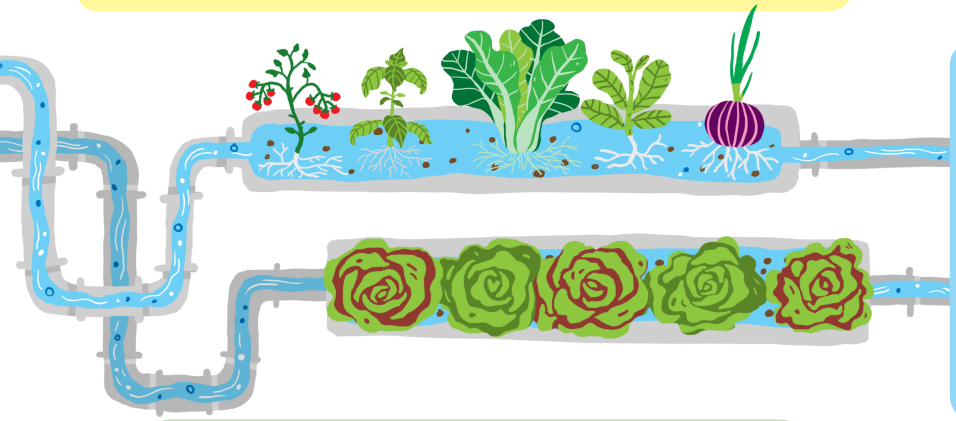
Mulching can help suppress weeds. It also keeps water in the soil, preventing plants from drying out. **Mulch** can be a great habitat for soil creatures.

Try not to squash down or tread on your soil too much – this leads to compacted soils. Insects, fungi, and plant roots can't move though compacted soil very easily – and neither can water or oxygen.

The Future

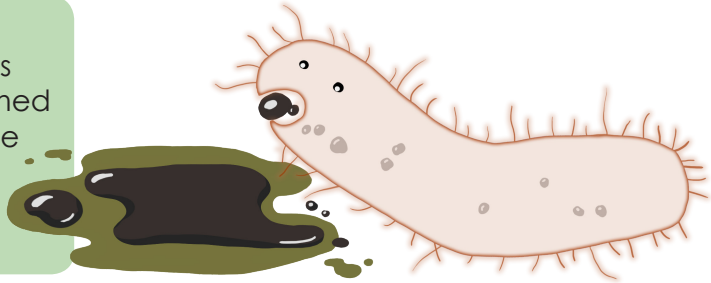
Scientists are working on exciting advances to help soils, humans, and our shared planet – take a look at the three examples below.

Attacking the plastic plague!
Under normal circumstances, plastics like PET (polyethylene terephthalate) take hundreds of years to decompose. But in 2016, in soil taken from near a bottle recycling facility, scientists discovered a species of bacteria that eats PET for breakfast! Before this, only a few organisms were known to degrade PET, and none so quickly. Now scientists have used these amazing bacteria to create a super-**enzyme** to help tackle plastic waste!



Five-a-day... without soil?
Hydroponics – a way of growing plants in a nutrient soup instead of in soil – could help ease pressure on soil and water. Astronauts have used it to grow salad in space! On Earth, solar energy can power hydroponics. With the cost of solar power falling, there might be a hydroponic farm coming near you!

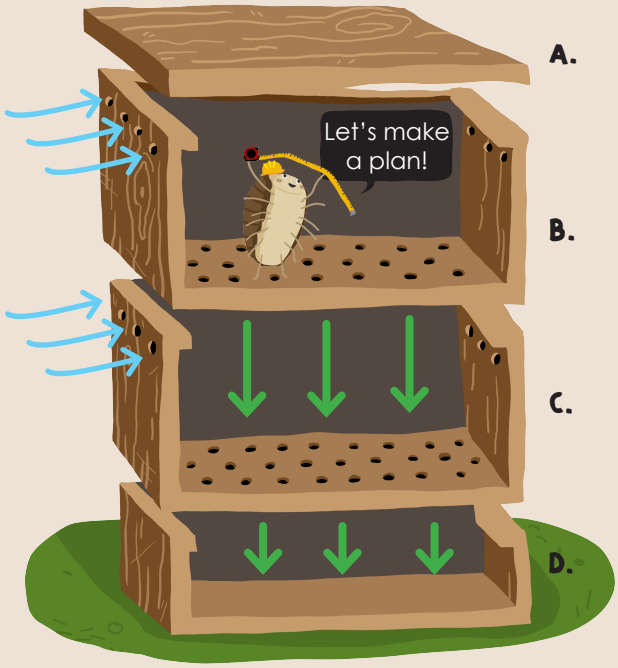
Bringing soils back from the brink
Some highly polluted soils, such as lands where oil has been spilt, can be reclaimed by soil-dwelling life! **Bioremediation** – the use of microorganisms like oil-eating bacteria to break down pollutants – can help to clean polluted areas.



Threats to soil threaten our environment, food, and health. **You can help** by caring for the soil around you, telling people about the importance of soil, and protecting the creatures who live in and around soil.

Creating Worm Compost

Waste worries worming away at you? Cast them away by putting the real worms to work. A worm farm is a natural way to reduce and recycle waste, while producing wonderful wormy compost! Try building one with your family, friends, school or community.



Construct your worm farm

A. The lid keeps everything dark and moist and stops the worms from escaping!
B. This is where you can add small pieces of food waste. Holes in the sides keep the air flowing.
C. The worms will eat the food and produce worm **castings** which fall into this middle box through the holes.
D. A nutrient-rich liquid known as "worm tea" drains into the bottom box.

If making your farm from wood is too tricky, try reusing old stackable plastic containers with lids. Ask an adult to help you punch the holes.

If you'd prefer to avoid plastic, try finding a three-tier steamer pot from a thrift store for a small worm farm.

The tiger worm, *Eisenia fetida*, and its relative *Eisenia andrei* are tireless worm farm workers. In the wild, they live on the surface, and don't burrow into the soil like other earthworms.

Using worms to break down organic waste produces '**vermicompost**'.

Fill your worm farm

1 → Start by placing a layer of moistened, shredded newspapers in the top box.
2 → Add a few handfuls of compost, some damp soil and your chopped-up food scraps.
3 → Add your worms and cover with more moist, shredded newspapers.
4 → Vermicomposting doesn't smell bad. If your worm farm starts to smell stinky, it means something is wrong!
5 → Place a baking tray in this box to catch the worm tea. Then use it to water your plants.

There are many wonderful resources and designs for different types of worm farms. Keep researching to learn all the details of vermicomposting!

Glossary

Bacteria Single-celled organisms, invisible to the naked eye. Bacteria are sometimes called germs, but not all bacteria cause disease.

Biodiversity The variety and variability of life in any given area.

Bioremediation The use of microorganisms to clean pollution from contaminated areas, including soils.

Castings Worm castings, essentially worm poo, are a great organic fertilizer.

Degraded soil Soil that has a poor condition owing to improper use or poor management – for instance by agriculture, industry, or other actors.

Desertification A process through which fertile land becomes desert, often resulting from drought, deforestation, or inappropriate agriculture.

Enzyme A substance produced by a living organism which speeds up the rate of a biochemical reaction.

Erosion Soil erosion is the loss of the upper layer of soil – a form of soil degradation.

Groundwater Water present beneath the surface of the Earth.

Hibernation An extended period of minimal activity or dormancy, often through winter.

Hydroponics The process of growing plants without soil, but with added nutrients.

Invertebrate An animal without a backbone, including insects, spiders, and crustaceans. Invertebrates represent about 95% of animal species.

Leguminous Plants in the legume family, including some beans, peas, lentils, and peanuts.

Microbe or **Microorganism** Tiny creatures, too small to be seen by the naked eye. They include bacteria, viruses, fungi, and protozoa.

Microbiome The human microbiome is the collection of all the life living on or inside your body, like on your skin or inside your gut.

Mulch A layer of usually organic material applied to the surface of soil to conserve soil moisture, improve fertility, reduce weeds, and so forth. It is often made of decaying leaves, bark, compost, wood chippings, well-rotted manure, straw, or seaweed.

Mycelia The vegetative parts of a fungus, consisting of branching, threadlike structures.

Nematode Also called roundworms, nematodes are small and worm-shaped with smooth, unsegmented bodies. There are many thousands of nematode species, most about 5 to 100 micro-metres thick and 0.1 to 2.5 mm long. The smallest are microscopic. Some free-living species can reach 5cm long, while parasitic nematodes can reach over a metre long.

Organic matter Carbon-based compounds made from the remains of organisms like plants and animals, as well as their waste products.

Protist A group of organisms made up of protozoa, unicellular algae, and slime moulds, protists are single-celled organisms that are not an animal, a plant, or a fungus.

Protozoa A kind of protist, for example, an amoeba.

Rhizomorph Fungal root-like structures that help fungus spread and grow.

Rhizosphere The region of soil close to plant roots, influenced by plant root growth, respiration, and nutrient exchange.

Salinization The process by which water-soluble salts accumulate in soil. It can occur naturally or result from poor management. Too much salt is bad for soil life, including crops.

Saprotroph An organism that feeds on decaying organic matter.

Tardigrade Minute animals, known as water bears or moss piglets, tardigrades have eight legs and are segmented.

Vertebrate Animals with backbones or spinal columns – including mammals, birds, reptiles, amphibians, and fishes.

Further Reading

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World Soil Day 2020

Keep soil alive, protect soil biodiversity

Biodiverse soils – those with a wide range of different plants and creatures – are essential.

"I believe soil is a living thing. That's what soil health means, soil is life. Every living thing has rights. Therefore, soil also has rights."

– Rattan Lal
Soil scientist and winner of the 2020 World Food Prize

This book was created for World Soil Day 2020, for the Food and Agriculture Organization (FAO) of the United Nations, the International Union of Soil Sciences (IUSS), and the Global Soil Partnership.

World Soil Day was first observed in 2014, and December 5th, 2020 marks the seventh World Soil Day.