
SOIL
BIODIVERSITY
WHAT'S MOST IMPORTANT?

Welcome to the soil fan club! This is where scientists from different laboratories meet and discuss their research on soil science. This year, the theme for the club is:

Soil Biodiversity

Soil is an ecosystem, with many living and non-living parts. In this club, we have many different scientists to help us understand soil biodiversity, and figure out what is the most important living part or group of organisms in soil. Meet the scientists!

Billy the botanist studies plant life

Edward the entomologist is a zoologist that specializes in soil insects

Mo the microbiologist studies microscopic life in the soil

Zoey the soil zoologist studies soil animals

Melody the mycologist is a microbiologist that specializes in fungi

Emily the ecologist studies the interactions among soil organisms and their environment

What is Soil Biodiversity?

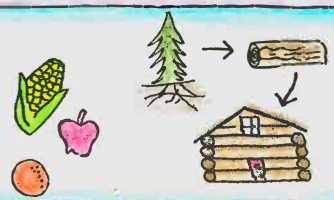
"Biodiversity is the variety of life on Earth," Emily the ecologist exclaimed. "This includes all living things, like plants, animals and microbes. So, that means that soil biodiversity is the overall diversity and variety of life in the soil" the scientists nodded in agreement.

"Biodiversity is important because as the number of different organisms increases, the benefits that flow to the ecosystem also increase" she continued. "Direct benefits to humans are called ecosystem services. Some examples of ecosystem services include:

Habitat for life, both in the soil and on it including for wildlife and people

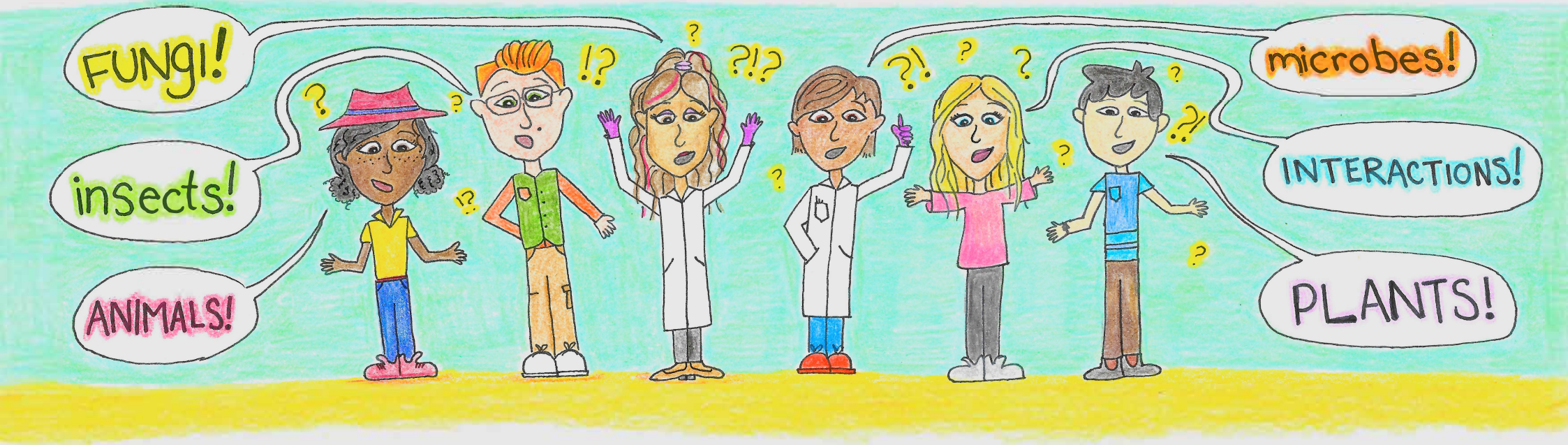
Nutrient recycling and storage in soil

Food and other materials we use for clothes or building



"In fact, the actual formation of soil itself can be considered an ecosystem service, since humans need the soil to grow plants for food and to keep life on the planet" the scientists agreed.

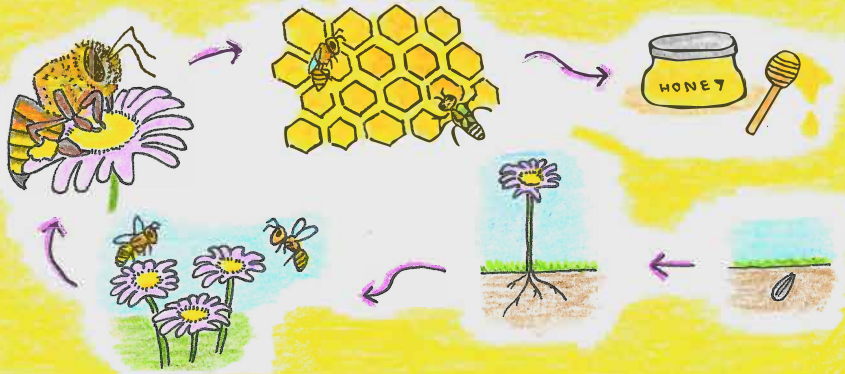
"We all study soil biodiversity! And we all agree which part of soil biodiversity is most important! It's the..."



The scientists looked at one another with confusion. They didn't agree at all! Clearly, the answer was not as easy as they thought...

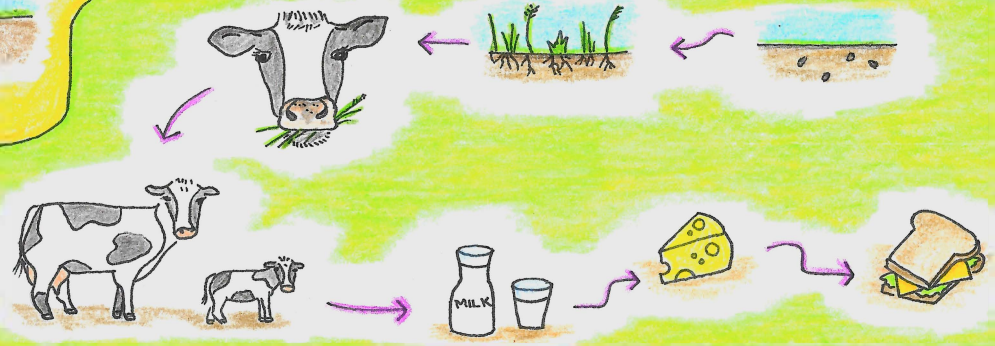
"I am a botanist. I have dedicated my life to studying plants. Nearly all of the plants I study would not be able to exist without soil, and one of the most important roles of soil is that it can support plant life. Planting seeds and growing food has been the goal of farmers and gardeners for a long time, and early civilizations thrived only when they were successful in protecting the soil and its biodiversity to support food production. Apart from seafood, most food comes from soil.

"Think about the cereal you eat for breakfast. The cereal came from wheat or oats, which started as a seed growing in soil.

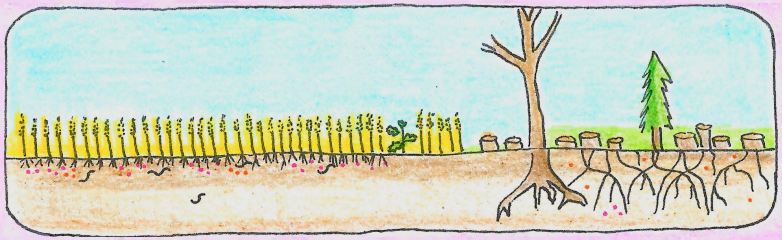


"Think about honey. The honey came from a bee hive. The bees collected pollen from many flowers to make the honey. The flowers were grown in soil.

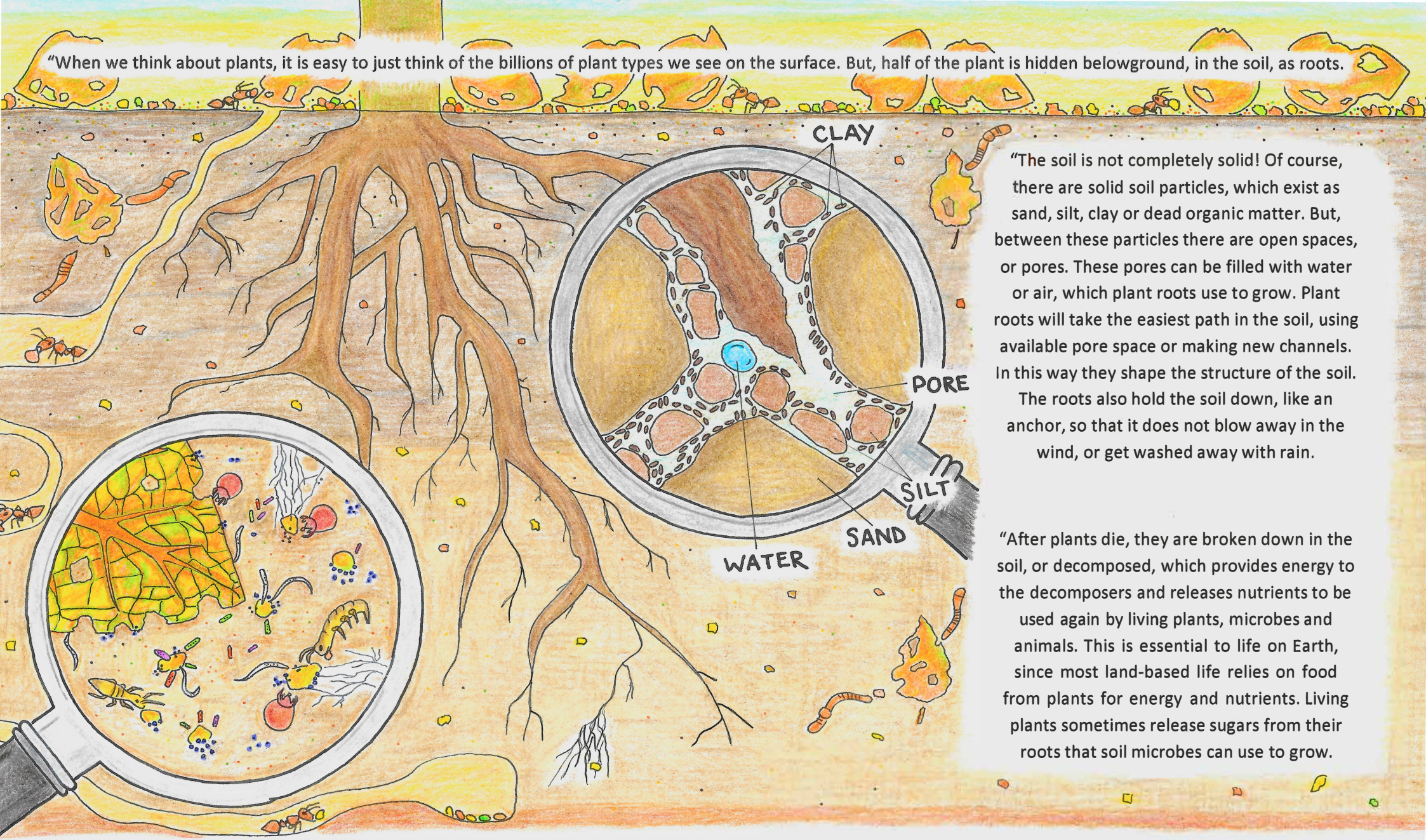
"Think about the slice of cheese on your sandwich. The cheese was made from cow's milk. The cow was fed grass in order to grow and be able to birth calves. The field of grass was planted in soil.



"When we look at an ecosystem, we see so many different plants! Plants can also increase the biodiversity that we cannot see as easily, because plants provide food for more soil insects and microbes. When we plant only one crop in a farm field, or when we cut down forests for their wood, we completely change the plant biodiversity that we see. But, we also change the biodiversity we cannot see, in the soil. As humans, it is our responsibility to consider this biodiversity when we use the soil.



"When we think about plants, it is easy to just think of the billions of plant types we see on the surface. But, half of the plant is hidden belowground, in the soil, as roots.



"The soil is not completely solid! Of course, there are solid soil particles, which exist as sand, silt, clay or dead organic matter. But, between these particles there are open spaces, or pores. These pores can be filled with water or air, which plant roots use to grow. Plant roots will take the easiest path in the soil, using available pore space or making new channels. In this way they shape the structure of the soil. The roots also hold the soil down, like an anchor, so that it does not blow away in the wind, or get washed away with rain.

"After plants die, they are broken down in the soil, or decomposed, which provides energy to the decomposers and releases nutrients to be used again by living plants, microbes and animals. This is essential to life on Earth, since most land-based life relies on food from plants for energy and nutrients. Living plants sometimes release sugars from their roots that soil microbes can use to grow.

"Since there are so many plants in the world, which feed almost all life on the planet, and because plants provide the basic resources for soil organisms to exist, I think that the plants are the most important part of soil biodiversity!"

"I am a soil entomologist, and I study insects. I think that the most important part about soil biodiversity is the diverse species of insects that we come across in the soil. Soil is home to many, many insects, so I will only discuss two of my favourites here, ants and dung beetles.

"Ants can be ecosystem engineers, which means that they have a great effect on the soil when they build tunnels and nests. The ants in a colony work together to reshape the soil ecosystem, mixing and increasing pores in the soil, moving plant materials, and some species even farm fungi to get energy and nutrients. The activity of ant colonies may change the soil faster and much more than what we might be expect for such small insects. Even though each ant is very small, because there are so many of them in the world, they actually make up more biomass, or weigh more, than the Earth's amphibians, birds, reptiles, and wild mammals combined!

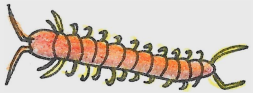
"Dung beetles are important in recycling dung from large herbivores, like grazing cows. To a dung beetle, fresh manure is a treasured source of food and building material. Some types simply live in the dung, while others move and reshape it, rolling it into balls and pushing it into tunnels in the soil. They feed on, reproduce in, and live in the dung. They even lay their eggs in it so that the larvae have a food source to eat.

"Can you imagine the world if animal dung was never decomposed?! Dung would quickly pile up, creating a mess that would smother the grassland so that the grass and animals that depend on it could no longer grow. Dung beetles do a good job of quickly breaking down the dung, which otherwise would happen much more slowly. Dung beetles help create healthy soils by returning nutrients to the soil by spreading and breaking down the dung so that plants and other living things can thrive.

"Since so many insects live in and on the soil, and because they change and add nutrients to the soil, I think that soil insects are the most important part of soil biodiversity!"



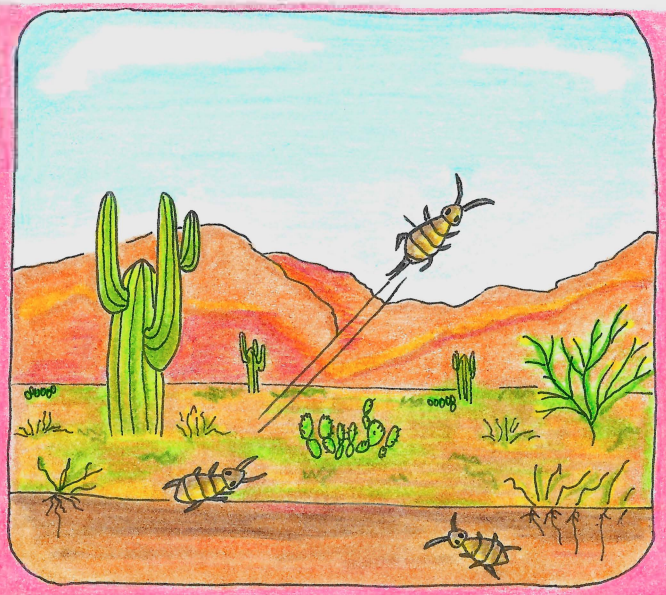
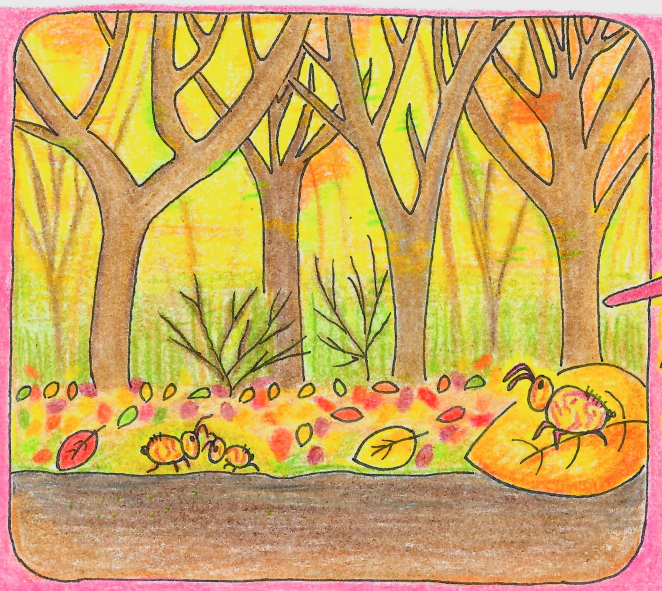
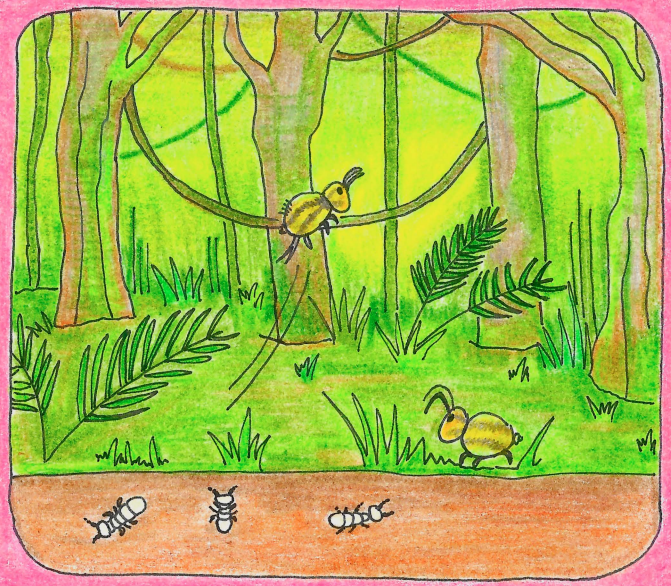
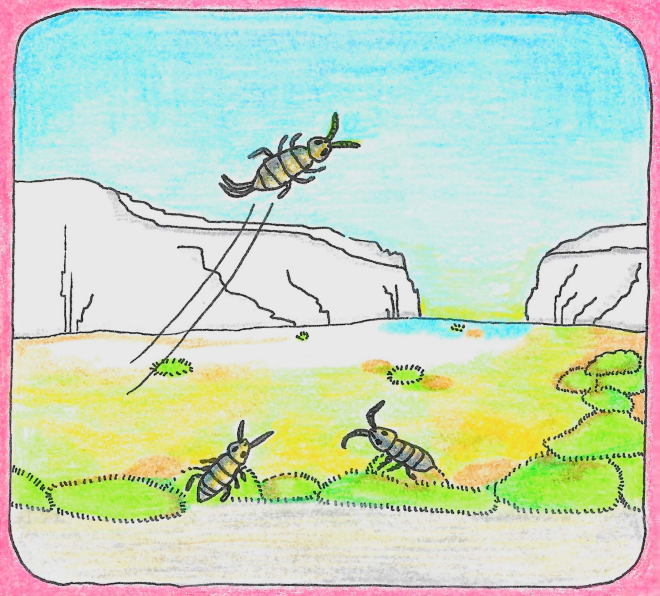

Zoey the Soil Zoologist



"I am a soil zoologist, which means that I study soil animals. I am interested in soil animals like springtails, mites, earthworms, millipedes, centipedes, and nematodes. Soil animals are very common; there may be many million of them in a square meter of soil. That's like having more than the population of your whole city within the span of your arms!

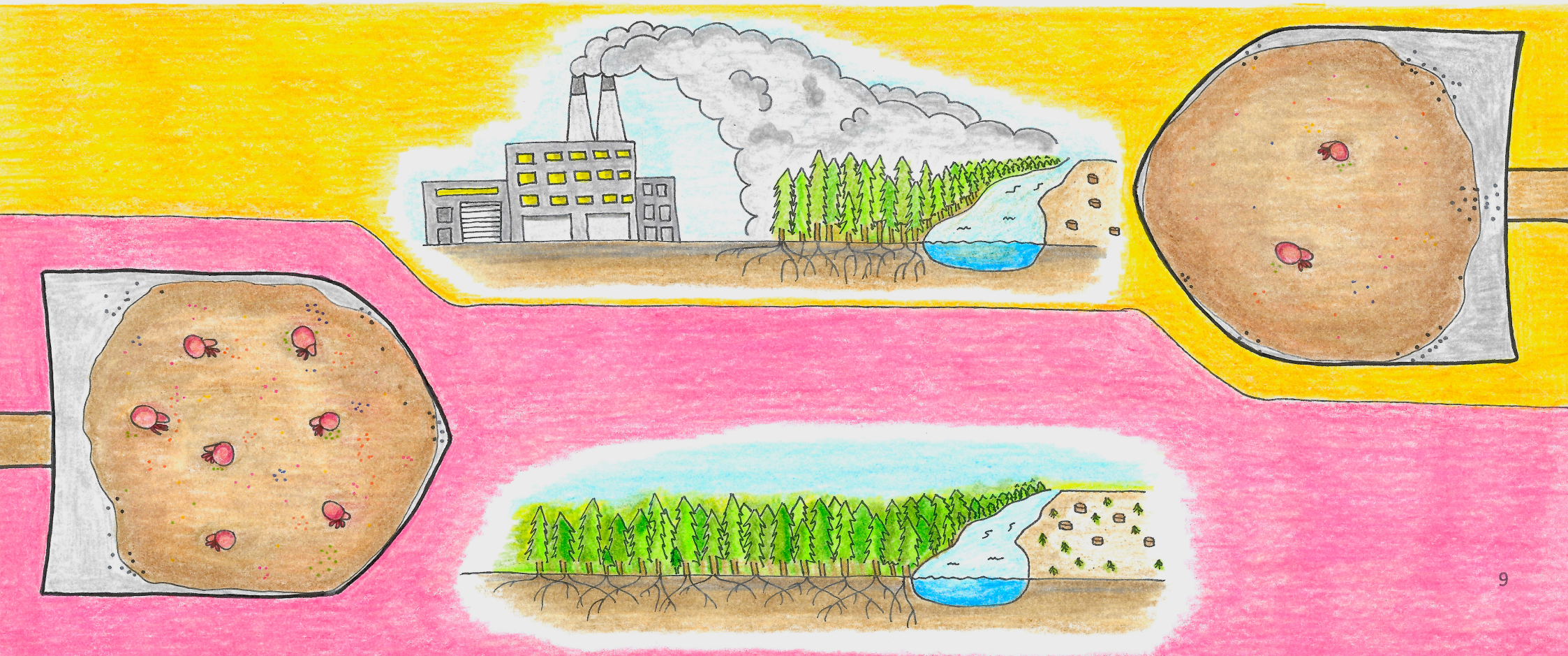
"Springtails are very small insect-like organisms. Springtails can use a small appendage, or tail, below their body to spring themselves into the air when they feel in danger. They can jump up to 10 centimeters in the air, which is like you or I jumping over a skyscraper. Springtails live all over the world, even in some of the most extreme soils, from the Antarctic, to deserts, to tropical jungles.

"In the soil, springtails shred, mix and eat dead plant material, returning nutrients to the soil as they dine. This helps to improve the environment for soil microbes and to increase soil biodiversity. But wait! Some springtails also like to eat bacteria and fungi, which changes the biodiversity of soil microbes too.


“Mites have similar roles to springtails in the soil; they also mix, shred and break down plant material, releasing nutrients and scattering soil microbes as they eat.

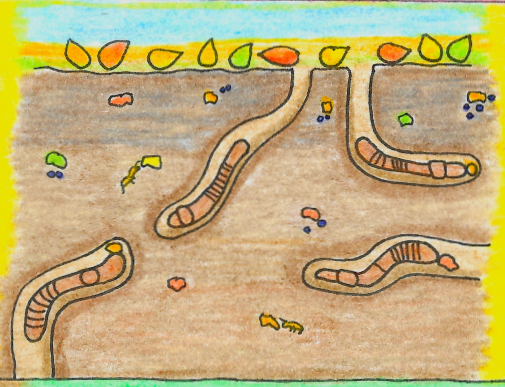
“One of the most common groups of mites, called *Oribatida,* has been used as a bioindicator. Bioindicators are living things that tell us about the health of their surrounding ecosystem. Imagine a forest growing next to a smokestack. Since trees grow slowly, it could take years before they become sick and die because of the pollution from the smokestack. By then, it may be too late for us to help. Bioindicators respond faster to changes and are easier to measure, so by looking at the soil mites, we can quickly determine if the pollution is damaging the ecosystem and fix any problems. Studying the biodiversity of these mites can give us an idea if the ecosystem is healthy or being stressed by disturbances such as mining, harvesting or climate change.

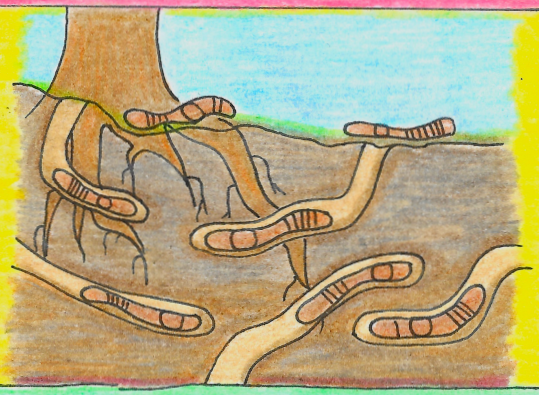


"Other long and skinny animals also live in the soil, including earthworms, centipedes, millipedes, and tiny nematodes!

"Earthworms can be ecosystem engineers, like ants. As earthworms tunnel through the soil they mix in plant materials. This helps decompose plants and provides food for other soil organisms.

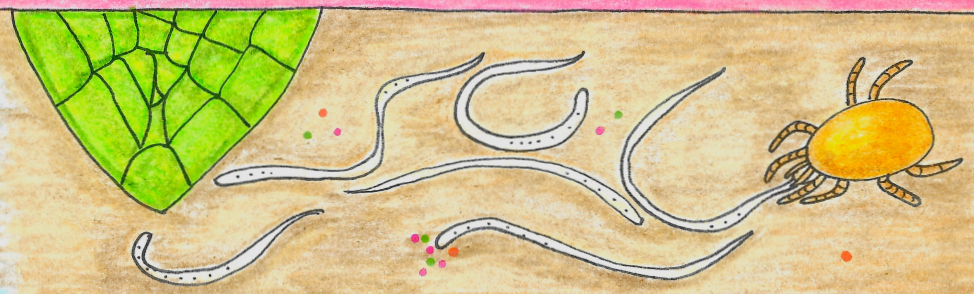
But, earthworms can also lower biodiversity in soils where they do not belong. Sometimes, their aggressive tunnelling changes forest soils so that other soil organisms have a difficult time finding familiar foods and habitats.





"As they eat, millipedes shred dead plant materials into smaller pieces, and mix it into the soil with smaller soil animals and microbes. Other soil animals would not be able to get as much food without the help of bigger animals like millipedes.

"Centipedes are predators, which mean they hunt other soil animals because they like to eat them. In this way, they help control populations living in the soil.

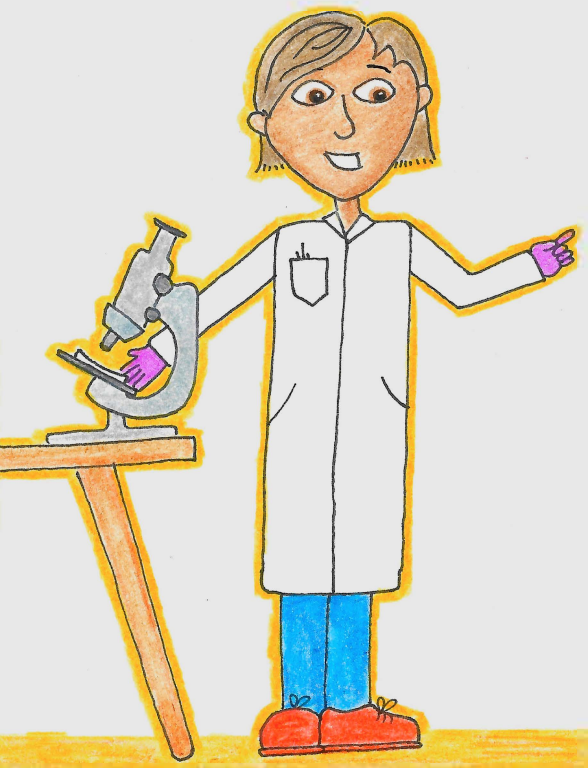


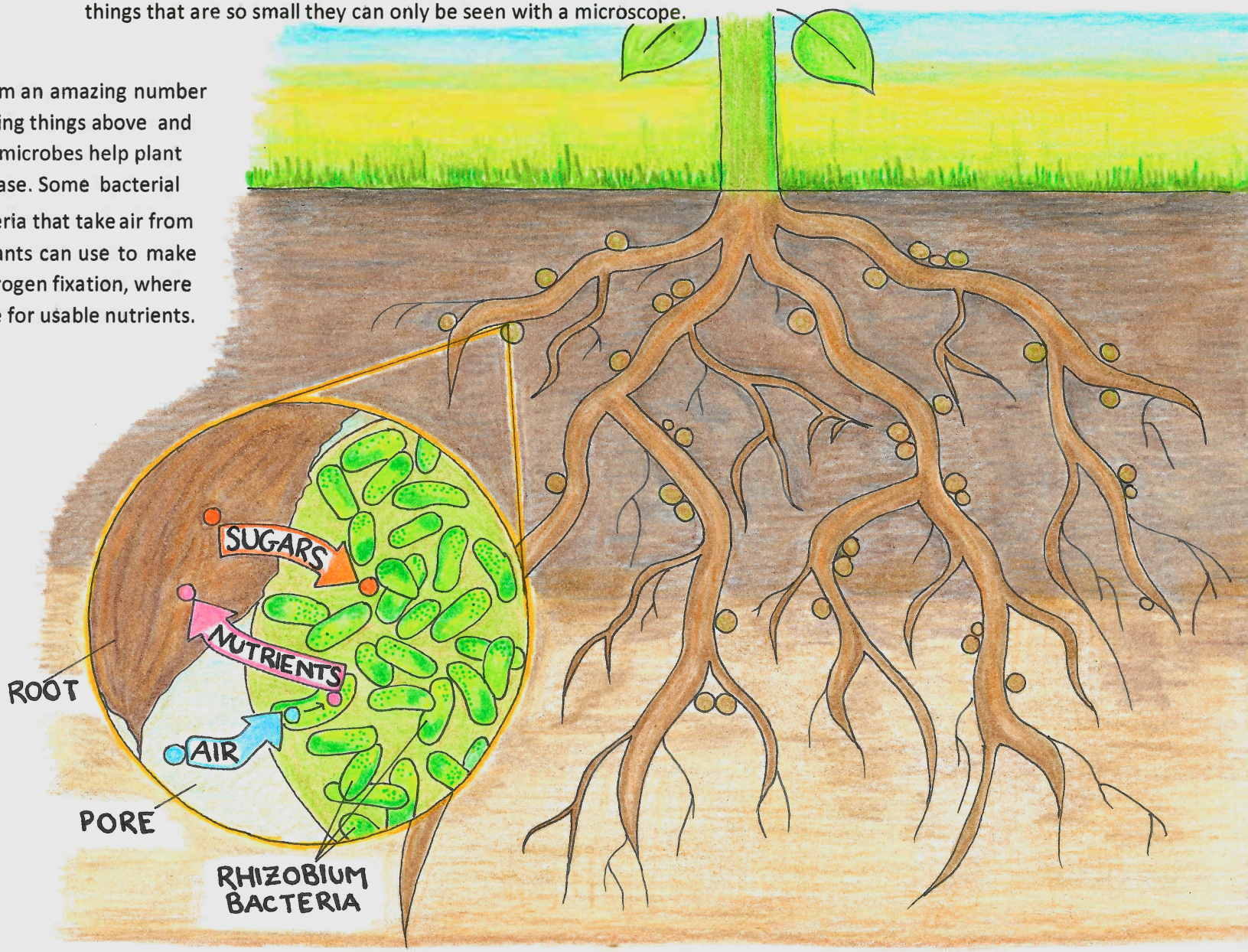
"Nematodes are tiny worm-like soil animals that are invisible to the naked eye. They feed on plants and microbes, and larger animals feed on the nematodes. Like mites, nematodes have been used as bioindicators. But, more nematodes does not always mean healthier soils, especially since some nematodes become pests when they chew on the roots of crop plants.

"Since there are so many soil animals that connect plants and microbes, I think they are the most important part of soil biodiversity!"

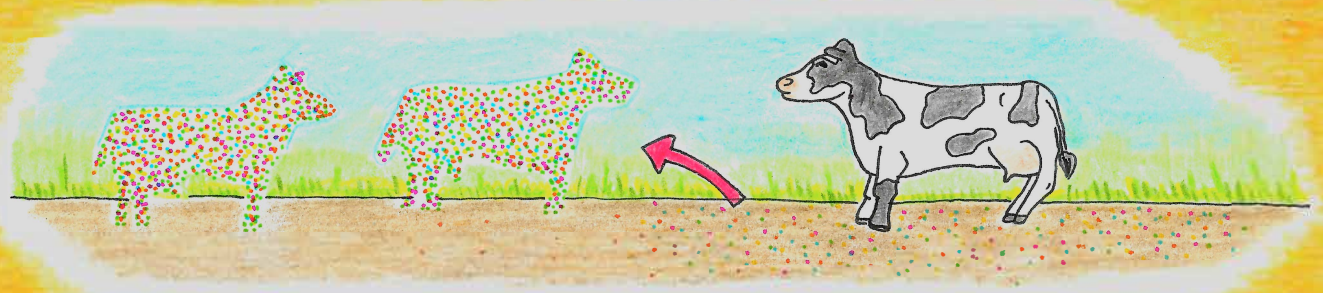
"For me, the smallest organisms are most important in the soil! I am a soil microbiologist, and I study soil microorganisms. Microorganisms, like soil bacteria, are living things that are so small they can only be seen with a microscope.

"Despite their small size, microbes can perform an amazing number of nutrient transformations, which impact living things above and below ground, including humans. Many soil microbes help plant growth while others sometimes cause disease. Some bacterial infections are beneficial, like *Rhizobium* bacteria that take air from soil pores, and change it to nutrients that plants can use to make valuable proteins. This is called biological nitrogen fixation, where the plant gives the bacteria sugar in exchange for usable nutrients.



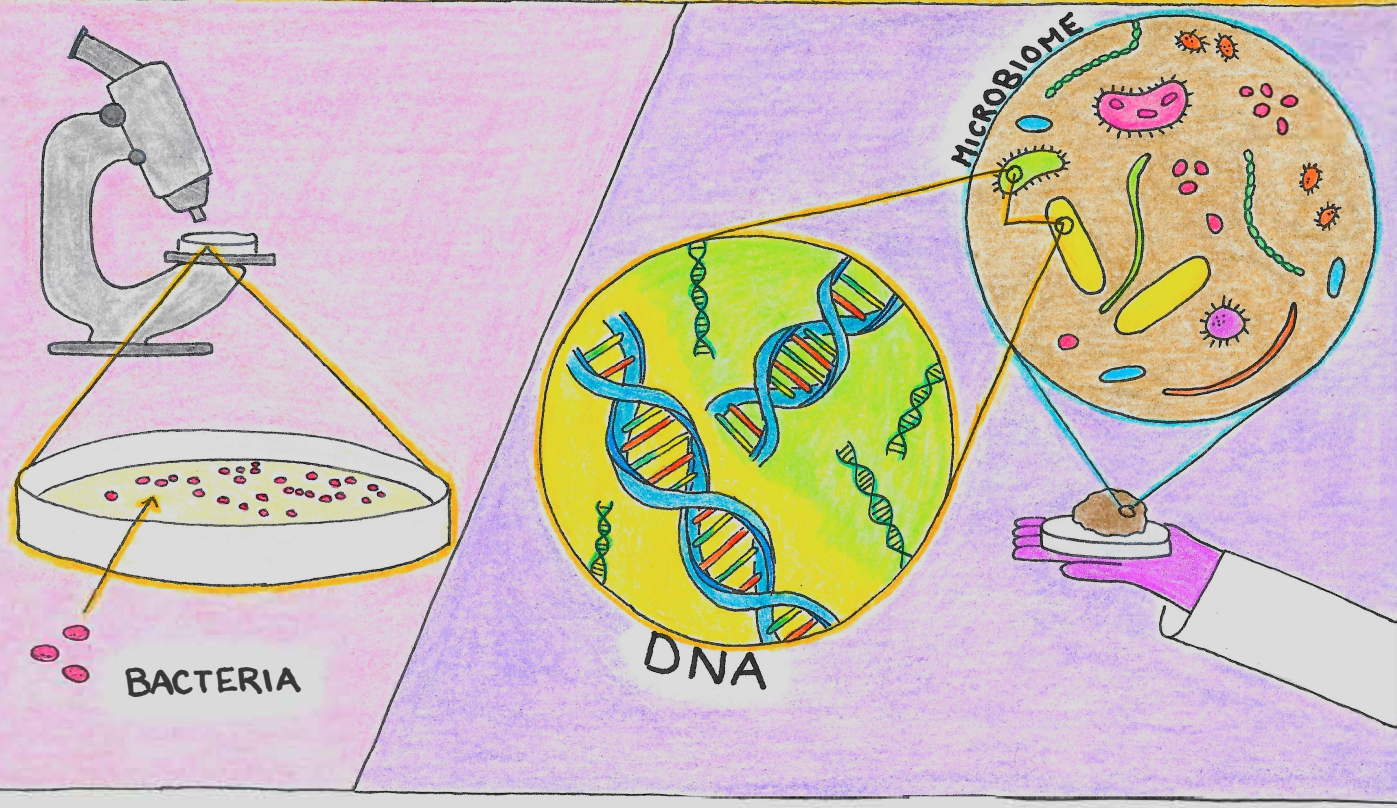


"Remember how ants have more biomass than most other animals on Earth? Well, bacteria have an even greater biomass than ants! Bacteria are second only to plants in global biomass. Even though bacteria exist only as a single cell, and animals are made up of many cells, the numbers of bacteria in a grassland soil are so huge they often weigh more than the cows grazing aboveground.



"Scientists can grow some types of soil bacteria on culture plates and study them using microscopes. But, there are too many types to study one at a time, and many cannot be grown in the lab. This means that we may not understand the full diversity of all the bacteria in the soil if we only use these methods.

Today, soil microbiologists like me use a new type of science called metagenomics to identify the entire community of soil microbes from their DNA, rather than having to identify each microbe individually. This way, scientists are learning about the soil microbiome, which is the entire variety of microbes found in soil. It is important to improve our understanding of these microorganisms, because they determine how ecosystems work, how our food is grown, and even provide medicines.



"In just one teaspoon of soil, there can be hundreds of millions or billions of bacteria. We have not discovered most of the microorganisms in the soil, and we have very little idea of their roles in the soil. There is so much room for more discoveries! Since they are so diverse, I think that bacteria are the most important to soil biodiversity."

Melody the Mycologist

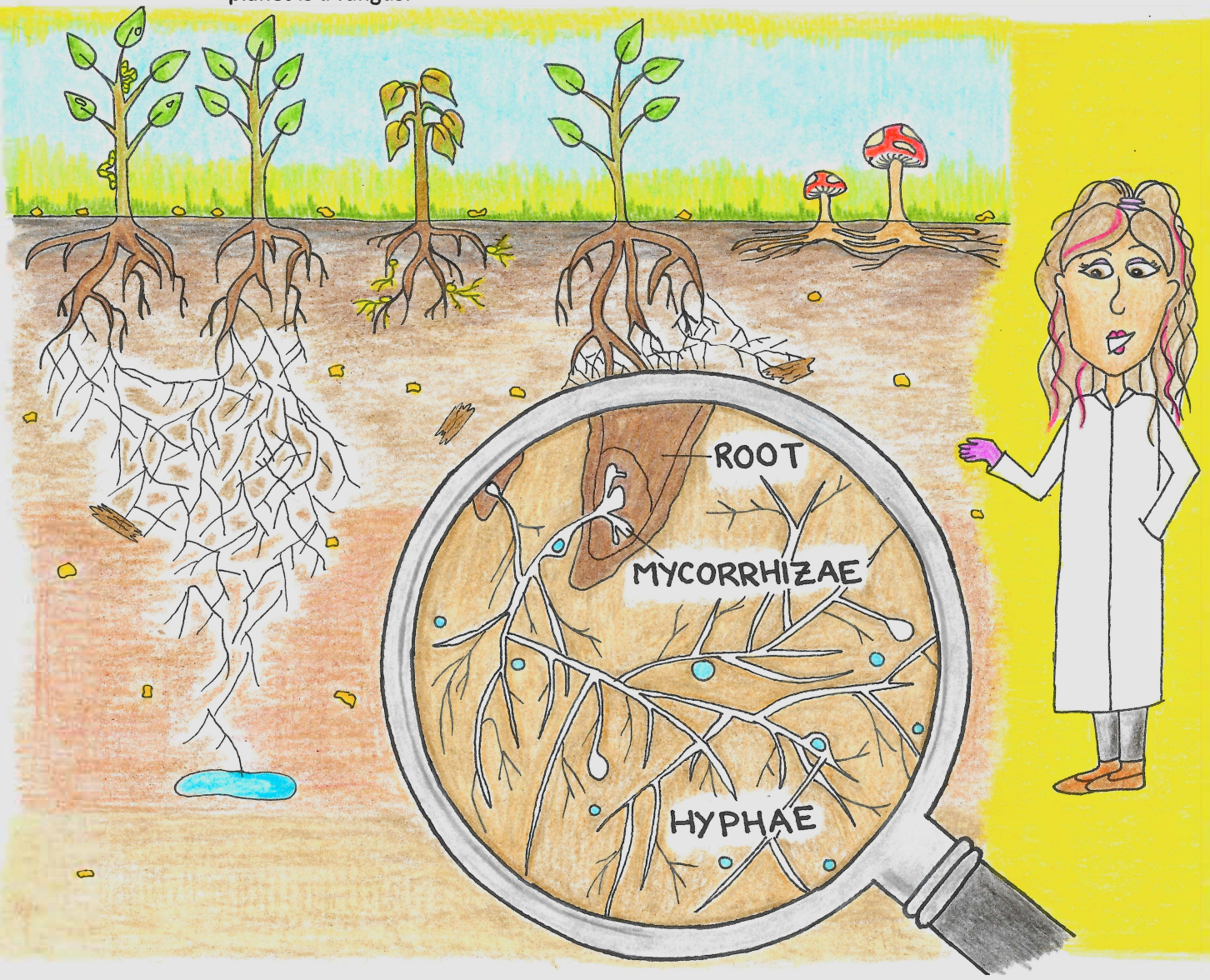
"As a soil mycologist, I study soil fungi and their relationships with plant life. Some fungi can grow bigger than elephants or blue whales. In fact, the largest organism on the planet is a fungus!

"Many soil fungi exist as long and thin interconnected strands called hyphae. Usually they are hidden belowground, but sometimes they form mushrooms, which we can easily see. Some soil fungi are powerful decomposers that can break down tough materials like wood. Other types of fungi can be pests that damage plant roots.

"Many soil fungi cleverly make a home in plant roots, and both the fungi and the plant depend on one another to live. We call them mycorrhizae, which means "fungus root". But why is it so successful?

"Mycorrhizae do not have to get food by decomposing materials; instead they get sugars from roots. In return, the fungi extend the root system and serve as tiny pipelines to move water and nutrients to the plant, accessing resources that may be out of reach.

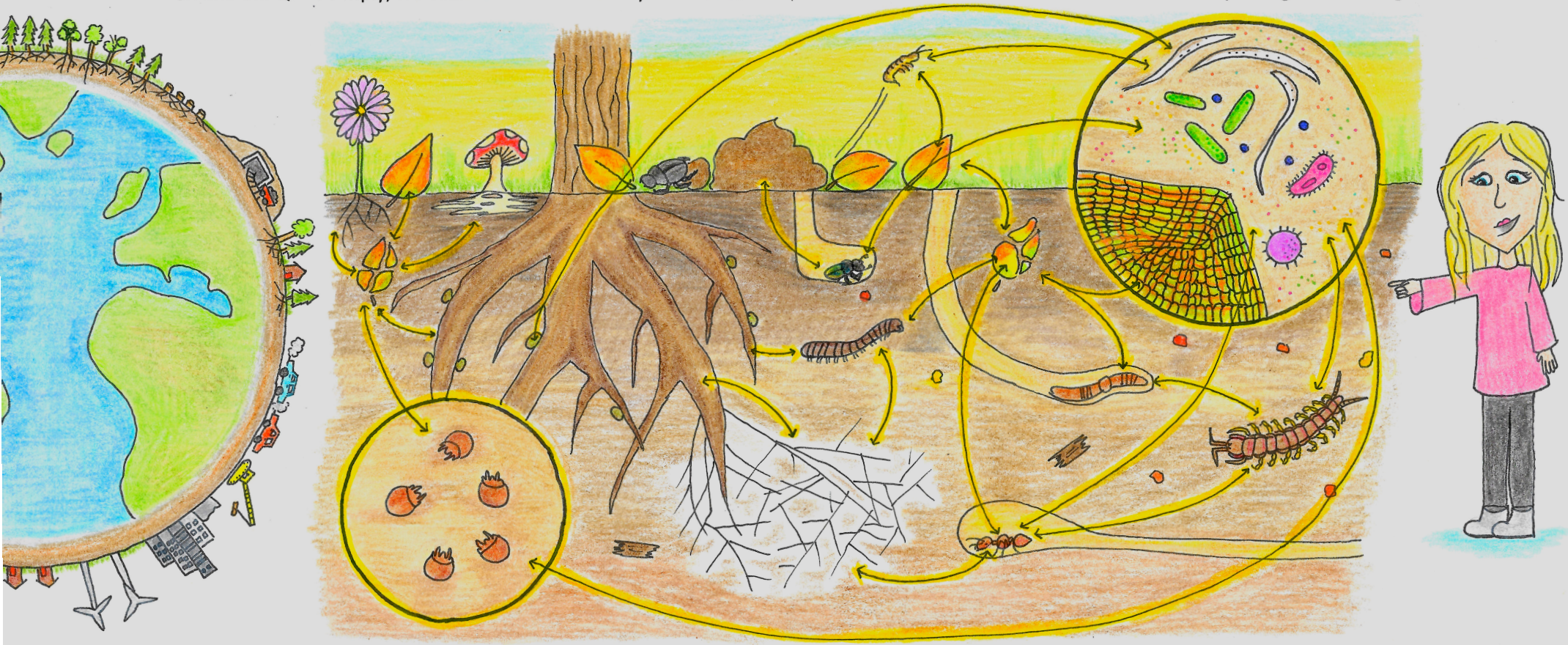
"Mycorrhizae may even help plants to communicate with one another by using chemicals. The plant will release a chemical from the roots, which travels through the hyphae, to other connected plants. In this way, a plant can warn their neighbours of an insect attack.



"Since fungi recycle soil nutrients, help plants to grow and communicate, and have such a large biomass in the soil, I think they are most important to soil biodiversity!"

"I agree with all my fellow scientists; every organism is important, from microbes to plants and everything else contributing to soil biodiversity. I am a soil ecologist, and I research the interactions among soil organisms and their surrounding environment.

"The soil ecosystem is a giant web, where everything is connected. Plants are connected to the soil microbes that transform nutrients for their roots to take up. Soil microbes are connected to the soil animals that spread and eat them. Soil insects are connected to plants that provide them with habitat and food. Soil animals are connected to soil insects that help to shred and mix materials into the soil for them to eat. There are so many connections among every group of organisms that I could go on and on. Quite simply, we cannot have biodiversity without the soil, and we cannot have soil without the biodiversity of organisms living there.



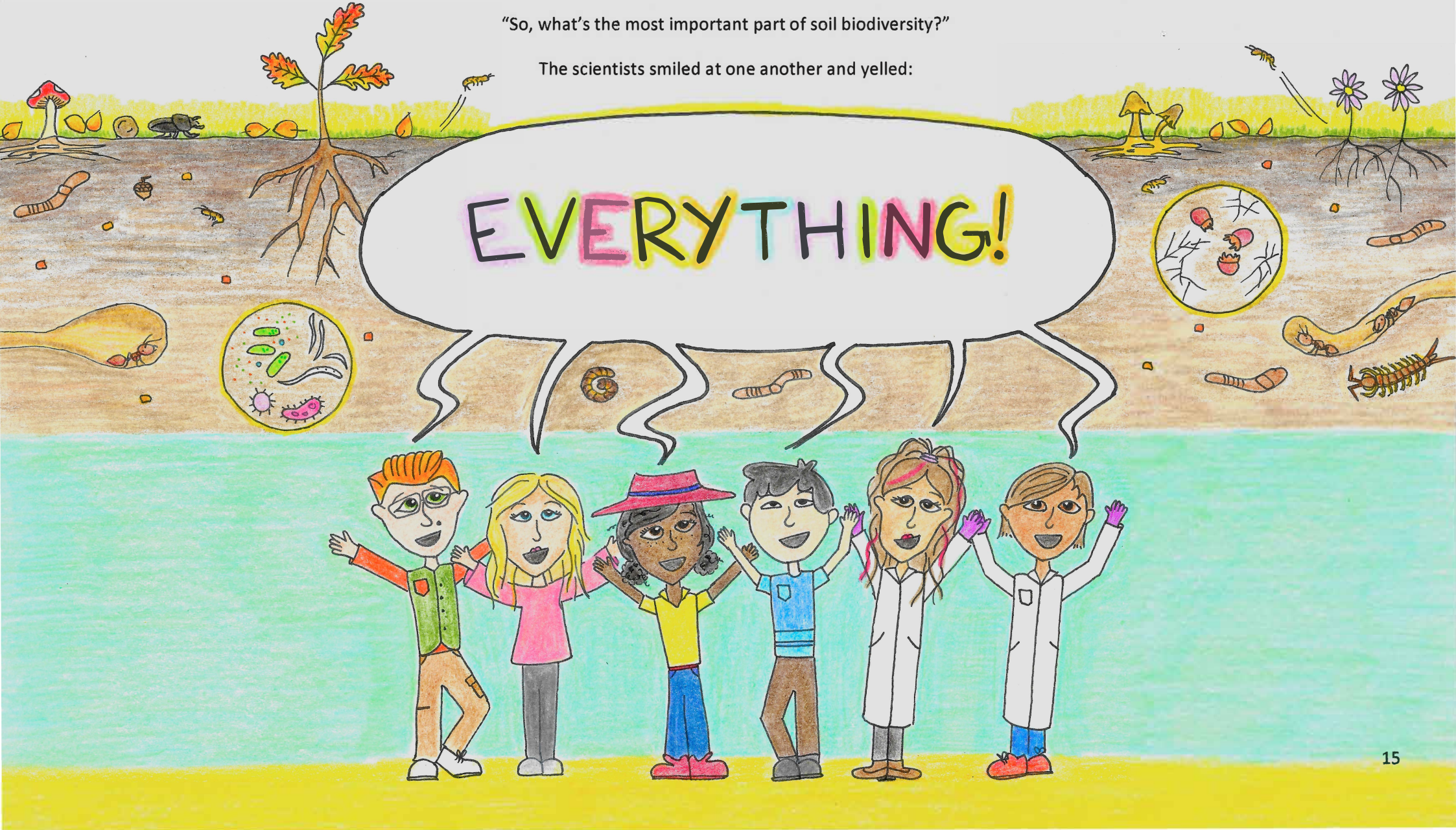
"When we use the soil, it is not enough to consider only the resources, such as food and trees, that we can use right now; we must think about the future. When growing food, cutting forests, mining minerals or building cities, we must always ask ourselves: 'will today's activities allow soil biodiversity to last so we will continue to benefit from the activity of soil organisms in the future?' because without proper care of our soils and the living organisms in them, we will not be able to keep life on our planet."

"Soil is so diverse, complicated, and packed with biodiversity, that all of us scientists must work together to better understand how soil biodiversity contributes to healthy ecosystems and the soil's ability to provide ecosystem services" Emily the ecologist finished.

The scientists smiled at one another. Finally they understood that they must work together to protect soil biodiversity, to keep soil alive and to keep life on Earth.

"So, what's the most important part of soil biodiversity?"

The scientists smiled at one another and yelled:



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