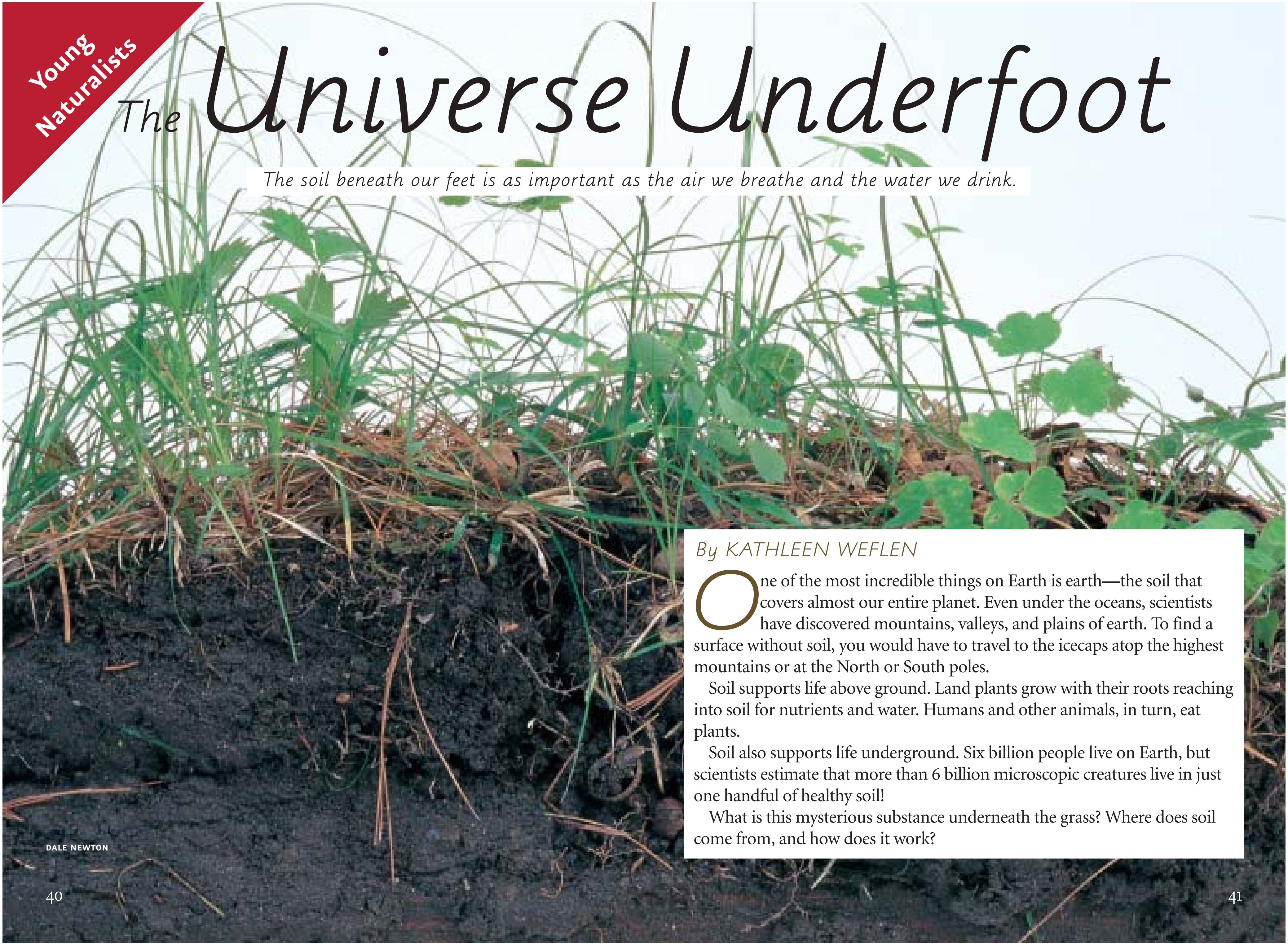
Young Naturalists

The Universe Underfoot

The soil beneath our feet is as important as the air we breathe and the water we drink.



DALE NEWTON

By KATHLEEN WEFLEN

One of the most incredible things on Earth is earth—the soil that covers almost our entire planet. Even under the oceans, scientists have discovered mountains, valleys, and plains of earth. To find a surface without soil, you would have to travel to the icecaps atop the highest mountains or at the North or South poles.

Soil supports life above ground. Land plants grow with their roots reaching into soil for nutrients and water. Humans and other animals, in turn, eat plants.

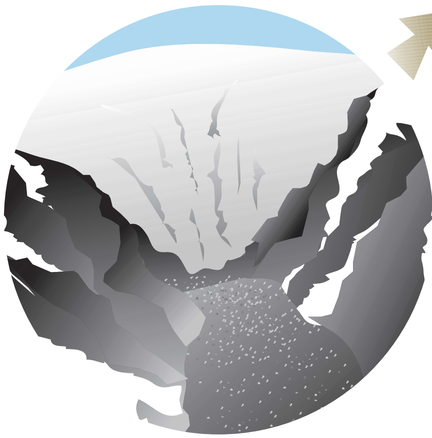
Soil also supports life underground. Six billion people live on Earth, but scientists estimate that more than 6 billion microscopic creatures live in just one handful of healthy soil!

What is this mysterious substance underneath the grass? Where does soil come from, and how does it work?

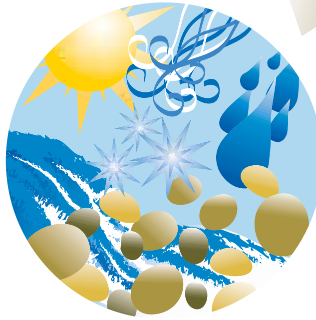
A Very Old Story

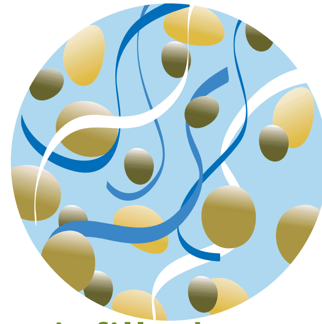
Natural forces form soil very slowly. Most soils in Minnesota have been forming for more than 10,000 years. Here's what happens.

Glaciers moved across the landscape, **cracking and crushing bedrock** into particles. These **particles** are actually bits of natural chemical compounds called *minerals*. For example, iron and quartz crystals are minerals in rocks.

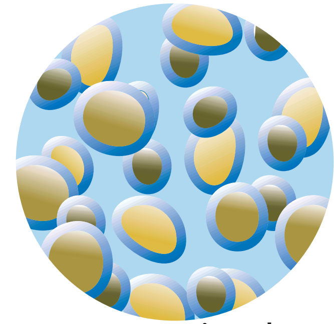


Wind, rain, rivers, plants, heat, and cold slowly continue to change mineral **particles.**



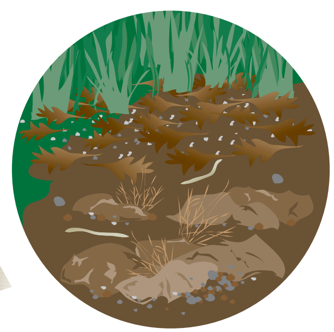


Air fills the spaces between particles.



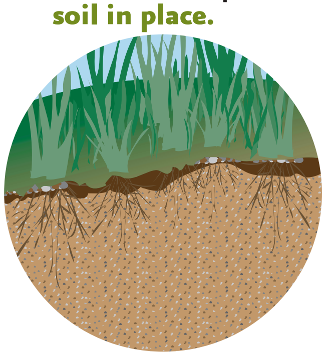
Rain and snow run into the spaces. **Water clings to particle surfaces.**

All kinds of **animal matter**—bones, eyelashes, snakeskin, moth wings, bird droppings—and all kinds of **vegetable matter**—flower petals, leaves, stems, banana peels—fall onto the ground.

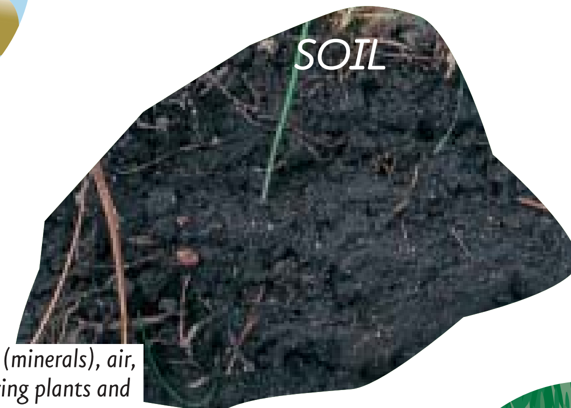


Bacteria, insects, molds, and other **decomposers move in** and digest organic matter, turning it into a crumbly, dark substance called *humus*. Worms mix humus into the mineral soil.

Burrowing critters such as gophers, moles, mice, snakes, beetles, and spiders make themselves at home underground, mixing particles and creating tunnels for **air and water** to enter.



Seeds sprout and send **roots** into the soil. Burly oaks, tall grasses, and other plants spread their roots wide and deep, **holding soil in place.**



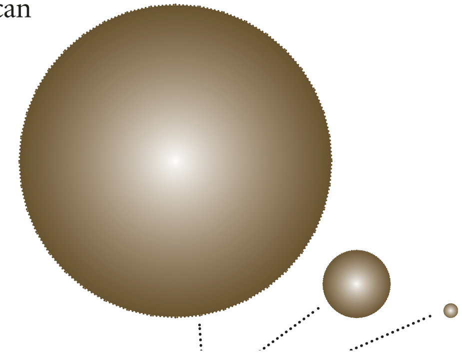
Soil is a mixture of bits of rock (minerals), air, water, organic matter (once-living plants and animals), and living things.

ILLUSTRATIONS BY STEVE MITZUK

Particles of Difference

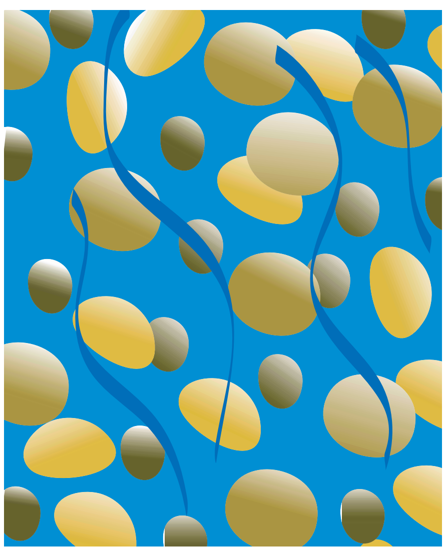
A scoop of soil from your back yard looks and feels different from a handful scooped up some other place, such as a lakeshore or a field. If you use a magnifying glass to examine mineral particles from each place, you can see the difference in the particle sizes.

Soil mineral particles are called sand, silt, or clay. Sand particles are the largest. Sand feels gritty. Silt feels as soft and silky as flour, and a silt particle is about the same size as a speck of flour. You need a magnifier to see clay particles, which are the tiniest. They feel smooth and sticky when wet.



Relative sizes of sand, silt, and clay

WHAT'S A PORE FOR? Like your skin, soil has pores, which are the spaces through which air and water move. To imagine how sand, silt, and clay particles fit together and form spaces, fill a glass jar with pebbles of various sizes and study the "pores." Add water and notice how air bubbles up as water runs into the pores.



PORES AND PARTICLES ILLUSTRATION BY STEVE MITZUK

Dirty Word?

People call earth different names. Soil scientists prefer to say *soil* because it simply means the surface layer of earth that supports plant life. *Dirt* has many meanings. It comes from the Old English word *drit*, meaning manure. The first dictionary definition of *dirt* is "any foul or filthy substance, as mud, grime, dust, or excrement [poop]." When manure or poop decomposes, it can become part of the soil. No wonder the word *dirt* can also mean soil.

GRAINY OR STICKY? The size and proportions of particles in soil give the soil its texture, which is the way the soil feels when you rub it between your fingers. Soil scientists group soils according to texture. Three common types are sand, loam, and clay soils.

Sand Soil. **About 75 percent of its particles are sand. Because sand particles are large and often about the same size, they don't squish together very well. Sand soil is porous—full of pores that allow water to enter and drain quickly.**

SOIL SAMPLE PHOTOGRAPHS BY DALE NEWTON

Loam Soil. **This kind of soil contains silt, sand, and clay. The particles can pack together well. The more silt in this mix, the fluffier and more crumbly it becomes (like a cake). When moist, a clump of this soil feels as light and bendable as Silly Putty.**

Clay Soil. **Because clay particles are smaller, they pack together with less air space. Water takes a long time to move through the tiny pores. Soil with 50 percent or more clay particles is heavy and sticky when wet.**

MOVING SOIL. Flowing water can pick up sand, silt, and clay particles, carrying them along in currents. As a current slows, it drops the largest particles (sand) first. Next, silt falls away. Tiny clay particles easily stay suspended, like cocoa powder stirred into milk. Clay particles usually sink last. In lakes and rivers, they fall to the bottom in the deepest places when waves or currents calm down.

Walking along Lake Superior, you can see how waves have sorted sand and rocks according to size. One beach may be all sand, another has only pebbles, and another is just large rocks.

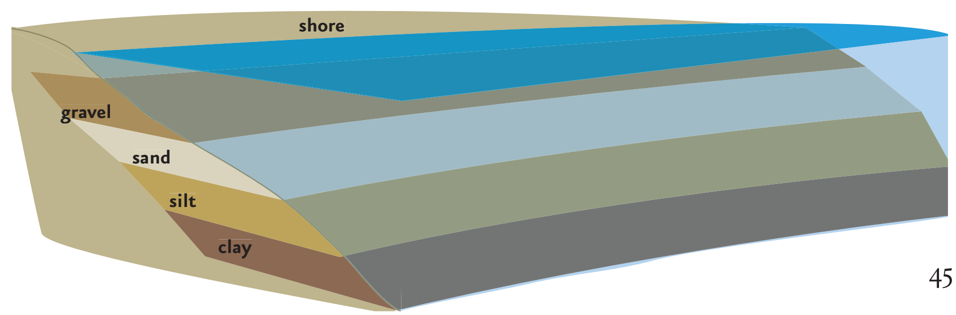


ILLUSTRATION BY STEVE MITZUK

From Frosting to Bedrock

Soil scientists dig into the earth to examine layers of soil called *horizons*. Together, the horizons create a *soil profile*, a kind of picture of how the soil formed, layer by layer, over time.

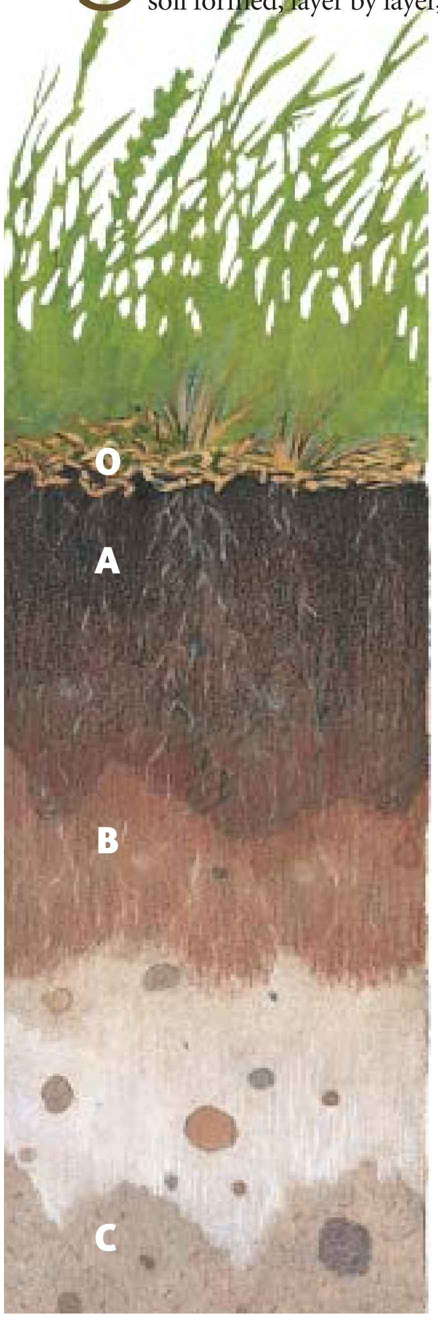


ILLUSTRATION BY DON LUCE, BELL MUSEUM OF NATURAL HISTORY

Horizon O is humus. Atop the soil, like frosting on a cake, humus is a dark, moist mix of decomposing plants and animals (organic matter).

Horizon A is topsoil. This layer is alive with critters and rich in mineral particles and decomposed organic matter. Minnesota farmland has topsoil up to 3 feet deep. Topsoil in forests is only 2 to 3 inches deep.

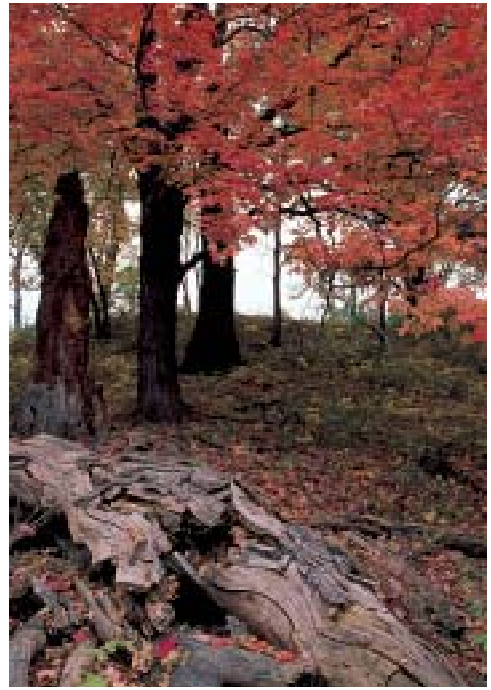
Horizon B is subsoil. This layer has fewer roots and creatures than topsoil does, but you can still find earthworms here. Water carries in mineral particles from above.

Horizon C is the parent material. This layer remains exactly as the glaciers deposited it. You'll find no plants or animals here.

Horizon R (not shown) is bedrock. This prehistoric layer of unbroken rock supplied minerals to the soil layers above. In a few places, such as along the North Shore, you can walk across bedrock. In most of Minnesota, bedrock is buried deep under the topsoil, subsoil, and parent material.

Typical prairie soil profile

***Kathleen Weflen** is editor of* Minnesota Conservation Volunteer.



FALL SUGAR MAPLES BY RICHARD HAUG

WHAT GROWS WHERE? What you see growing above ground is a clue to the soil below. Sugar maple trees, for example, need to keep their roots moist but not soaked. What kind of soil holds moisture best? Silt loam soil. Pine trees, on the other hand, prefer well-drained sandy soil.

Loam soil works best for growing corn, wheat, potatoes, and other food crops. It contains silt, clay, and sand, so it holds lots of water and nutrients yet it drains well. Most southern Minnesota farms have loamy soil.

EARTH COLORS. If you were a painter mixing up soil colors, you would start with mineral particles as your base. Sand particles, for instance, come in many colors. Add air, water, and organic matter in varying amounts, and you change the color of the soil.

Iron colors much of Minnesota's soil. Just as oxygen reacts with iron and turns a nail rusty, iron in soil reacts with oxygen, creating shades of red and orange. To get yellows or browns, add organic matter.

Water can displace oxygen in soil pores and thus change soil color. The longer and more deeply soaked the soil is, the less oxygen the soil has in its pores. Soil without oxygen turns blue or blue-gray. Blue clay soil and blue sand soil have lots of moisture and little or no oxygen.

DALE NEWTON

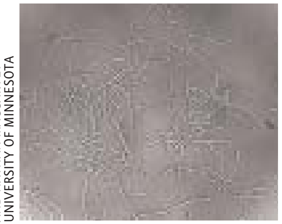
Just as painters might use a color chart to match and describe paint colors, scientists describe soil color by matching soil samples to a Munsell color chart.

Who Lives Underground?

Countless organisms must live and work together to keep enriching soil. Pick up a pinch of topsoil and you may be holding a billion microscopic organisms called *microbes*. Soil creatures, large and small, form a community called a *food web*. Their eating habits vary: Some get nutrients by decomposing organic matter, some shred, and some eat more or less as humans eat. Here's a look at some of them.

DECOMPOSERS

Bacteria. These microscopic organisms decompose all kinds of organic matter, releasing nutrients that plants can use. Sniff a handful of earth. The familiar, fresh aroma of moist, healthy soil comes from a substance released by *actinomycetes*, a group of soil bacteria.



YUN SHEUNG KYUNG AND NATHAN MACCARVEY UNIVERSITY OF MINNESOTA

Actinomycetes

Fungi. You can almost always find mushrooms, molds, and other fungi in the woods. Fungi decompose dead wood and other organic matter. A teaspoon of forest soil may hold tens of miles of fungal threads called *hyphae*.

Certain fungi form massive webs of hyphae called *mycorrhizae* around roots of certain plants. The mycorrhizae take up soil nutrients and water and pass them along to the plant. The plant roots, in turn, share carbon and energy captured from the air and sun.

E.R. DEGGINGER DEMBINSKY PHOTO ASSOCIATES

Mushrooms

E.R. DEGGINGER DEMBINSKY PHOTO ASSOCIATES

Mycorrhizae

SHREDDERS (Invertebrates)

Arthropods. Beetles, spiders, mites, millipedes, and other arthropods are invertebrate animals (no backbone) with jointed legs, segmented body parts, and an exoskeleton. They shred plant debris.

Annelids. Annelids are segmented worms, such as earthworms. They are important links in the soil food web. Besides shredding, they dig tunnels that let in air.

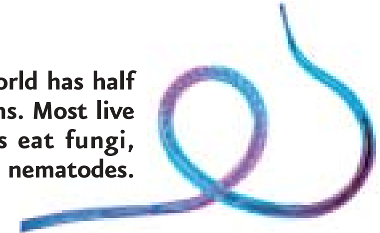
E.R. DEGGINGER DEMBINSKY PHOTO ASSOCIATES

Red velvet mite

Millipede

E.R. DEGGINGER DEMBINSKY PHOTO ASSOCIATES

Nematodes. Scientists estimate that the world has half a million species of nematodes, or roundworms. Most live in soil. Some of these unsegmented worms eat fungi, some eat bacteria, and some prey on smaller nematodes. All release nutrients back into the soil.



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Nematode

Tardigrades. In 1994 two German researchers discovered tiny tardigrade fossils more than 500 million years old. About 400 tardigrade species exist today. Known as water bears, most live in watery films on mosses, leaf litter, lichens, and soil. If you look at this tiny, eight-legged creature under a magnifying lens, you can see it lumbering along like a bear.

If its watery world dries up, it withers and wraps itself in a kind of skin. When water returns, the water bear perks up. One book tells of a dry piece of moss that sat on a museum shelf for 120 years. When someone moistened the moss, guess what came lumbering along!

MARTIN MACH

Tardigrade

GO-BETWEENS (Vertebrates)

Many vertebrate creatures (with backbones) move between the world underground and the world above. Some tap into the underground food web. Robins, for instance, tug up earthworms.

Various **mammals, birds, reptiles,** and **amphibians** spend time underground. They dig burrows for hunting, traveling, nesting, and hibernating. What have you seen disappear into a hole in the ground?

SKIP MOODY, DEMBINSKY PHOTO ASSOCIATES

Young thirteen-lined ground squirrel

DOMINIQUE BRAUD DEMBINSKY PHOTO ASSOCIATES

Robin feeding young with earthworm

Mighty Earth Movers

What moves tons of earth? Steam shovels, road graders, and earthworms. An earthworm gobbles up leaves and vegetable matter. It pushes them through its intestinal canal; then poops crumbly soil, called *castings*. In a year, all of the earthworms on an acre of farmland can move at least 20 tons of earth above and below ground.

Though earthworms enrich farm soil and lure fish to your hook, don't throw leftover bait worms into the woods. Scientists recently discovered that earthworms are hogging all of the leaf litter in some hardwood forests. Certain insects, fungi, and plants also need leaves to live.

E.R. DEGGINGER, DEMBINSKY PHOTO ASSOCIATES

A SCIENTIST WONDERS ABOUT WORMS AND SOIL

A few months after the British scientist Charles Darwin returned from his famous voyage to the Galapagos Islands in 1837, he went to visit his uncle in the country. As they walked in the garden, the uncle pointed out a spot where he had spread ashes and lime several years earlier. The spot had become buried in soil cast by earthworms. Astonished to see that worms could make so much soil, Darwin went home, lined the shelves of his study with glass-covered pots full of earth and worms, and began a series of experiments that lasted 40 years.

How did earthworms form soil? Darwin wondered.

Studying the worms' digestive system, Darwin wondered if they could taste and smell food. He observed them digging deep into the soil to reach cabbage and onion bulbs. He fed them and saw that they preferred green cabbage to red. They liked celery better yet and carrots best of all.

To see if worms could see, Darwin went to his study in the dark and shone light from candles, lanterns, and other sources on the worms. His findings agreed with those of today's scientists: Earthworms cannot see, but they sense light and dark. They crawl up above ground at night when birds and other predators probably can't see them.

To test the worms' hearing, Darwin watched for a response to sound when his grandson blew a whistle, his son tooted a bassoon, and his wife played the piano. Seeing no movement, he concluded the worms were deaf. However, when Darwin put the pots on the piano and plunked a key, the worms apparently felt vibrations and burrowed deeper into the soil.

With one long experiment, the scientist demonstrated his patience. Darwin spread a layer of chalk on a grassy field and waited 29 years to come back and dig a trench to see how deep the earthworm castings piled up. He found the chalk below 6 inches of soil!

Lost Topsoil

Wind and rain are blowing and washing topsoil from the land every day. This natural process, called *erosion,* first caught the attention of Americans during the 1930s. Then rain seldom fell, and winds whipped tons of dry earth into black clouds that rolled furiously across the land. The storms, known as dusters, started in the Great Plains states, which came to be called the Dust Bowl.

The Dust Bowl was farm and cattle country, but first it had been prairies. When European settlers came to Minnesota and other Plains states, they plowed prairies and planted wheat and other crops. For centuries the deep-rooted prairie grasses and wildflowers had held most of the soil in place, so that strong winds and hard rains could not carry it away. Farm crops simply could not hold it as well. Bare soil (plowed and unplanted) could not stay in place at all.

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Dust storm, Elkhart, Kansas, 1937

When farmers lose topsoil, they also lose the nutrients and microbes needed to grow food. The lost soil often ends up in lakes and streams, where it muddies the water and makes life more difficult for plants, fish, and other critters.

Today conservationists try to slow down erosion by plowing less, keeping the land covered with plants, and planting trees to break the wind.

Noteworthy Web Sites

www.acornnaturalists.com **Hand lenses and other resources for trails and classrooms.**

www.bellmuseum.org/learnkits.html **or 612-626-2299. *Get Dirty! Soils in Minnesota*, learning kit for grades 4, 5, and 6.**

www.fieldmuseum.org/ua/node_2.htm **Virtual underground tour.**

www.uen.org/projects **Activities for grade-school classrooms.**