All the Dirt on Soil

Want to drive a gardener crazy? Call that stuff that plants are growing in "dirt" instead of "soil." What's the difference? Dirt is what you track into the house on your shoes. Soil is an amazing and complex ecosystem that is one of our planet's most valuable natural resources. It's a mix of inorganic minerals, water, air, organic matter from dead and decaying plants and animals, and an incredible array of living organisms, ranging in size from microscopic bacteria and fungi to earthworms, moles, and shrews. In addition to anchoring roots, soil provides plants with life-sustaining water and nutrients. Plants in poor soils will struggle to grow, even if optimal water and light are available. In contrast, plants in good soils will grow to their fullest potential and experience fewer problems with insects and disease.

The topmost layer of this vital blanket, called topsoil, is the most productive one. It's the layer with the most biological activity and where most plant roots are found. The soil we farm and garden in has formed slowly over eons as a result of physical and chemical weathering breaking down bedrock, to which plants and animals have added their remains. This is by no means a speedy process – it can take more than 500 years for one inch of topsoil to form! Besides serving as the foundation for terrestrial plant growth on the planet, soil also filters and stores water and plays a major role in storing carbon, a critical function in this era of climate change.

Help your students begin to understand the importance of soil stewardship by digging into soils this spring. Here are some fun facts and an activity to get you started, along with links to additional resources to give you all the dirt on soil!

Exploring soil texture

Weathering is the process that turns solid rock into tiny particles and the simpler chemical elements that rocks are made of. Physical weathering is caused by the forces of wind, water, temperature change, and the action of rocks grinding against other rocks; even pressure from the roots of plants. Chemical weathering happens when minerals within rocks are released and changed into new chemical combinations when the rocks are exposed to water or to acids produced by soil organisms or the decomposition of plants.

Soil formation begins with bedrock, gradually adding layers or horizons with time, but it is not static process. While soil can form in place from the weathering of bedrock below, soil particles can also be carried by wind and water far from their original rock source. The topmost horizons contain the most organic matter and the greatest biological activity. Below this is the subsoil, consisting mainly of weathered rocks and minerals with only a little organic matter. Even deeper is the parent material consisting of rock particles and minerals with no organic matter, and below that the unweathered bedrock.

The tiny rock particles that the weathering of rock produces are called sand, silt, or clay, depending on their size. Sand particles are the largest; silt particles are smaller than sand; and clay particles the smallest of all. (If you think of a sand particle as being the size of a basketball, a silt particle would be the size of golf ball, and a clay particle only the size of the head of a pin!) The relative amounts of these different size particles determine soil texture. Soil that has a lot of sand or large particles has large pore spaces between particles and drains quickly, sometimes too quickly for plants growing in it, but it is easy to work. Soil that has a lot of small clay particles has smaller pore spaces between particles and drains slowly; it may stay too wet for healthy plant growth and roots may suffer from a lack of oxygen, but can be rich in minerals. Soil with lots of medium sized silt particles, called loam, falls somewhere in between.

While there's no such thing as a perfect soil, particular plants have adapted to growing in particular soils. In general, common garden plants prefer loam - soils with a balance of different-sized mineral particles (approximately 40 percent sand, 40 percent silt, and 20 percent clay) and ample organic matter and pore space, but some common plants grow better in sandy conditions, while others are well adapted to clay soils.

Adding organic material can offset many of the problems associated with both sandy and clay soils. Incorporating organic matter such as compost will improve water and nutrient retention in sandy soils and increase drainage and aeration in clay soils.

Assessing soil texture differences

Your students can carry out an easy experiment to find the relative proportion of sand, silt, and clay in various soil samples. You'll need:

- 2 cups of soil from each of 3 different locations
- 3 quart-size glass jars with lids (such as a canning jars)
- 3 teaspoons powdered dishwasher detergent
- Water
- Ruler
- Wax pencil

1. Spread the soil out on some newspapers and remove any stones, roots, etc. in the soil, keeping each soil sample separate from the others. Crush any large clods.
2. Have the students begin by squeezing a handful of lightly moistened soil from each sample into a ball. Does it stick together in a ball? If it forms a ball, does it crumble easily when poked? Next have them roll the soil between their thumbs and index fingers, noting how it feels – gritty, smooth, or sticky. Soil with a lot of sand feels gritty and won't form a ball, while soil that has a lot of silt particles feels smooth and forms a ball that crumbles when poked gently with a finger. Soil that is high in clay is sticky and forms a tight ball that doesn't break apart easily. Have the students keep track of their observations in a table and decide which type of particle – sand, silt, or clay – predominates in each sample or if it feels like they are found in equal proportions.
3. Next, place about 1 cup of soil from one sample in a quart-size glass jar. Add enough water to fill the jar about ¾ full. Add 1 teaspoon of powdered dishwasher detergent (this acts as a surfactant to help disperse soil particles). Put the lid on the jar and shake well for at least 5 minutes.
4. Set the jar on a flat surface. After one minute use a ruler and a wax pencil to mark the level on the outside of the jar of the sediment that has settled out. This is the sand layer. After two hours mark the top of the sediment level above the sand layer. This is the silt layer.
5. After 1-3 days, when the water at the top of the jar is clear (or almost clear) mark this last layer of sediment. This is the clay layer. (Some very fine particles may stay in suspension indefinitely, so the water may never clear completely.)
6. Measure the thickness of each layer that was marked on the jar, as well as the total thickness of all the sediment in the jar. Calculate the percentage of sand, silt, and clay in each sample. For example, divide the thickness of the sand layer by the total thickness of the sediment to get the percent of sand.
7. Repeat this procedure with each of the remaining 2 soil samples.
8. Compare the percentages of sand, silt, and clay with the assessments based on feel. Are the results what you expected? (It takes as little as 20% clay to make soil feel clayey, while it takes 45-60% sand to make it feel sandy!)

Over 200 billion garden helpers

Show students a cup of soil taken from an undisturbed area of native soil and ask them to estimate the number of organisms living in it. Let them dig around in the soil to see if they can see any creatures in it. Unless they find a stray earthworm or possibly some tiny mites or springtails if they look closely, it's likely they'll say that there aren't any living creatures present. But they'll be off on the order of billions! While there may not be any that you can see with the naked eye, if you looked through a microscope at the same soil sample, you'd be overwhelmed. There could be as many as 200 billion bacteria, 20 million protozoa, 100,000 nematodes, and 100,000 meters of fungal hyphae in that cup of soil!

Many of those microscopic organisms benefit plants, either directly or indirectly. (Of course, some soil microbes cause plant diseases, while others have no effect on plants, for good or bad.) A special type of bacteria, called rhizobia, inhabits nodules on the roots of legumes (plants like peas and beans). In return for some food from the plant, the rhizobia take up or "fix" nitrogen (an essential plant nutrient) from the air, where it is not in a form available to plants, and change it into one that plants can take up and use. This is a good example of a symbiotic or mutually beneficial relationship between plants and soil microbes.

Mycorrhizae (my-cor-rye-zay) on plant roots are partners in another type of symbiotic relationship. Mycorrhizae are fungi that form an association with the roots of specific plants (their name translates as "fungus root"). The fungi receive nutrients from the plant; in return, they enlarge the surface area of the roots, allowing them to take up water and nutrients for the plant more effectively.

There are also untold numbers of soil microbes that help plants less directly by breaking down organic matter and changing the nutrients it contains into forms available to plants. As these decomposing microbes break down organic matter, they also produce natural "glues" that bind soil particles into aggregates, enhancing soil structure and improving soil drainage and aeration.

What do all these millions or billions of garden helpers need to keep them happy? Adding organic matter like compost to the soil keeps these beneficial microbes thriving. If you have a school garden, remind your students of all the creatures they're supporting as they spread compost on the soil this spring.