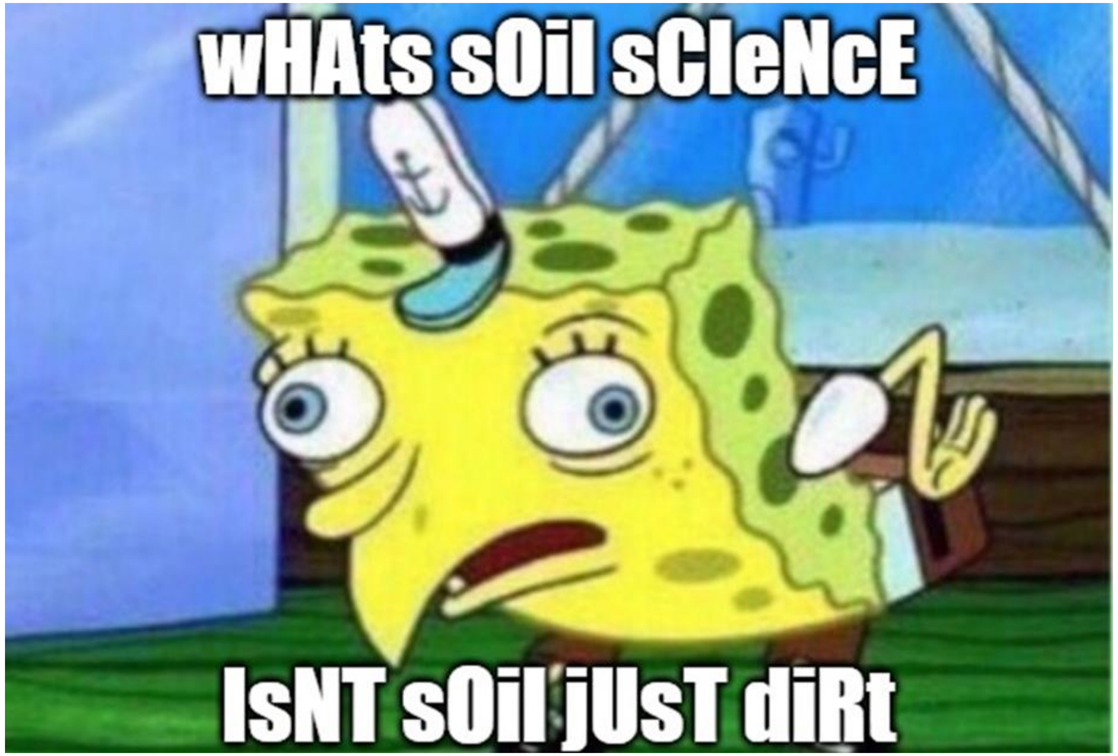
Soil Science

What is Soil Science?



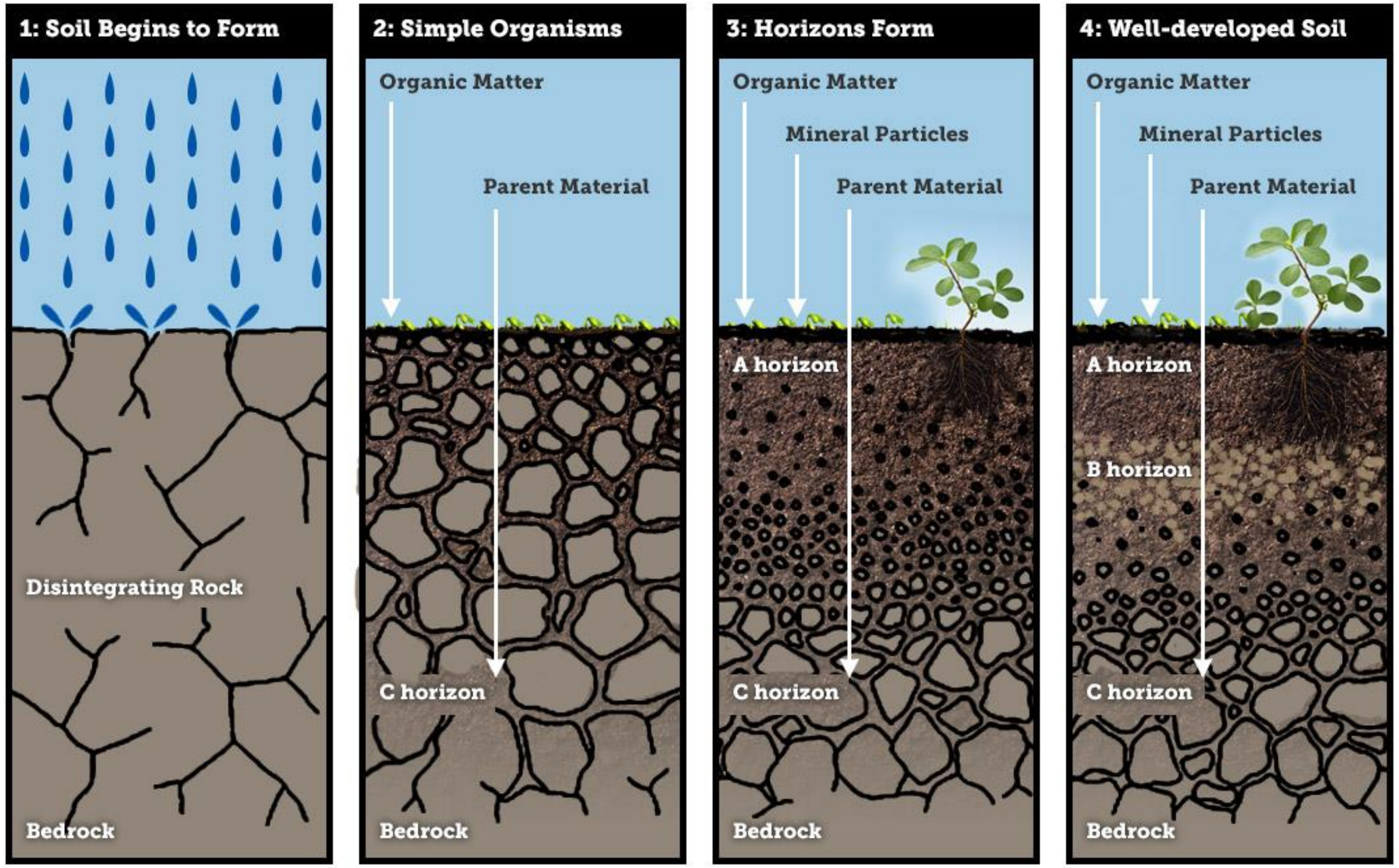
- Soil science deals with soils as a natural resource on the surface of the Earth: including soil formation, classification, and mapping; physical, chemical, biological, and fertility properties of soils; and these properties in relation to the use and management of the soils.
- Soils are not only the resource for food production, but they are the support for our structures, the medium for waste disposal, they maintain our playgrounds, distribute and store water and nutrients, and support our environment.
- Soil is a complex natural body composed of mineral and organic solids, gases, liquids, and living organisms.
  - 45% Minerals(clay, silt, sand, gravel, and stone)
  - 25% Water
  - 25% Air
  - 5% Organic Matter (both living and dead organisms)

Inorganic: Mineral Components

- Parent rock is broken down after thousands of years of weathering to produce soil.
- Three types of parent rock:
  - **Igneous** are formed through the cooling and solidification of molten rock from the earth's core.
  - **Sedimentary** are formed when older rocks are broken apart by plant roots, ice wedges, and earth movements and become transported by glaciers, waves, currents, and wind.
  - **Metamorphic** form when pressure and temperature, below Earth's surface, are great enough to change the chemical composition of sedimentary and igneous rocks.

Parent Material

- Parent Material: "the rock material usually unchanged or only slightly changed that underlies and generally gives rise to the true soil by the natural process of soil development"



CLORPT!

- Soils develop as a result of the interactions of climate, living organisms, and landscape position as they influence parent material decomposition over time. Differences in climate, parent material, landscape position, and living organisms from one location to another as well as the amount of time the material has been in place all influence the soil-forming process.
  - **CL**imate - Temperature and moisture influence the speed of chemical reactions, which in turn help control how fast rocks weather and dead organisms decompose. Soils develop faster in warm, moist climates and slower in cold or arid ones.
  - **O**rganisms—Plants root, animals burrow, and bacteria eat – these and other organisms speed up the breakdown of large soil particles into smaller ones. For instance, roots produce carbon dioxide that mixes with water and forms an acid that wears away rock.

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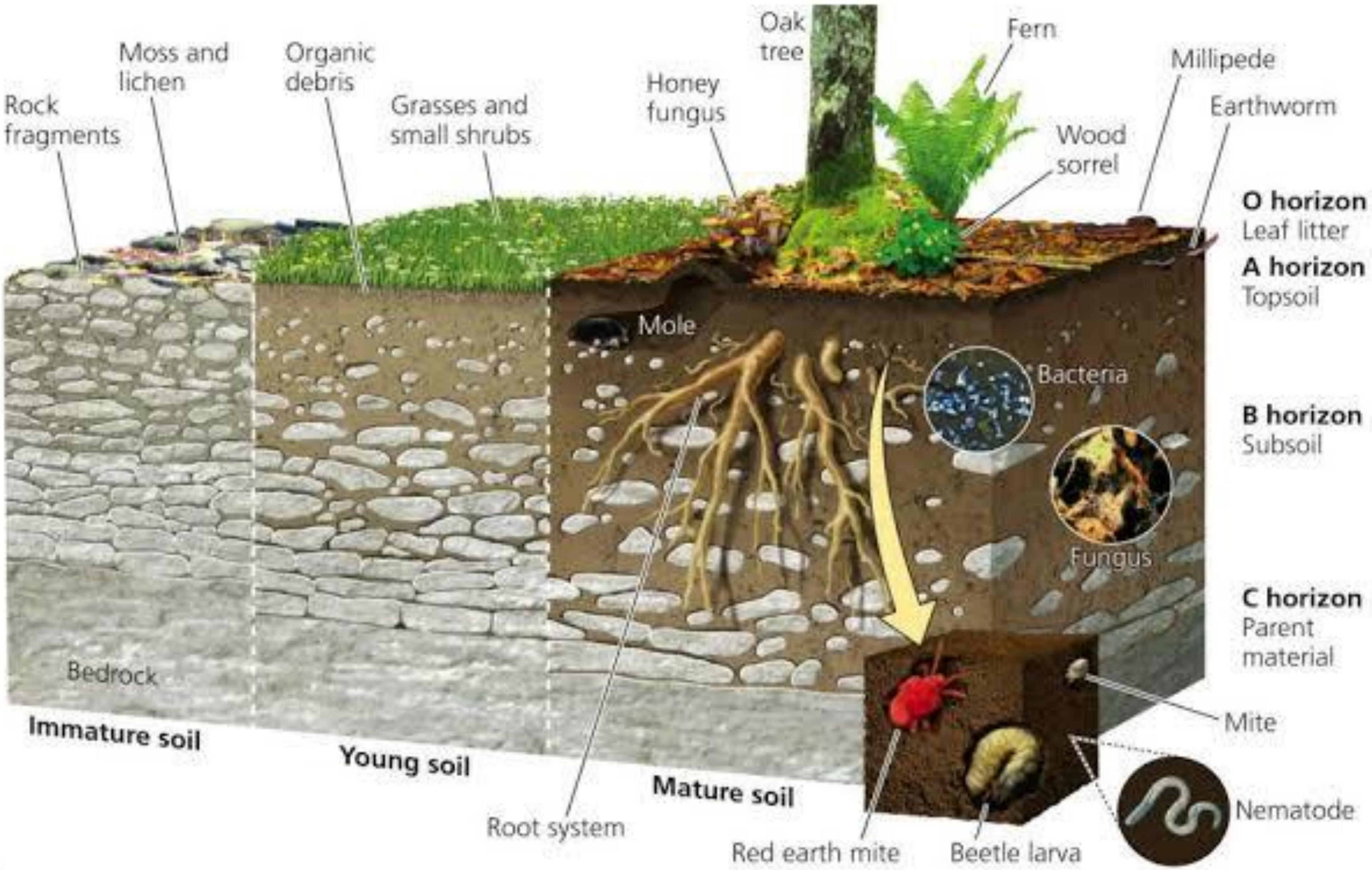
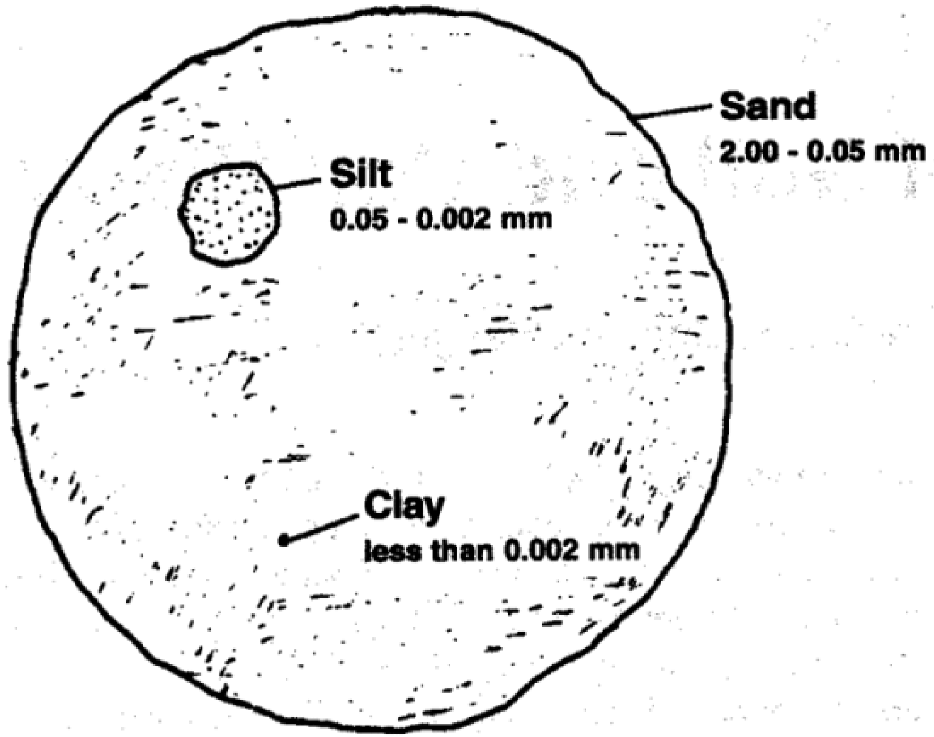
- **R**elief (landscape)—The shape of the land and the direction it faces make a difference in how much sunlight the soils gets and how much water it keeps. Deeper soils form at the bottom of a hill because gravity and water move soil particles down the slope.
- **P**arent material—Every soil “inherits” traits from the parent material from which it formed. For example, soils that form from limestone are rich in calcium and soils that form from materials at the bottom of lakes are high in clay. Every soil formed from parent material deposited at the Earth’s surface. The material could have been bedrock that weathered in place or smaller materials carried by flooding rivers, moving glaciers, or blowing winds. Parent material is changed through biological, chemical and environmental processes, such as weathering and erosion.
- **T**ime—All of these factors work together over time. Older soils differ from younger soils because they have had longer to develop. As soil ages, it starts to look different from its parent material. That is because soil is dynamic. Its components—minerals, water, air, organic matter, and organisms—constantly change. Components are added and lost. Some move from place to place within the soil. And some components are totally changed, or transformed.

Soil Formation Over Time



Soil Particles

- Beyond occasional stones, gravel, and other rock debris, most of the mineral particles are called sand, silt, or clay.
  - **Sand**: Range in diameter from 2 mm to 0.05 mm, are easily seen with the unaided eye, and feel gritty.
  - **Silt**: Range between 0.05 mm and 0.002 mm and feel like flour.
  - **Clay**: Smaller than 0.002 mm and cannot be seen with the unaided eye. Clay particles are the most reactive mineral ingredient in the soil. Wet clay usually feels sticky.

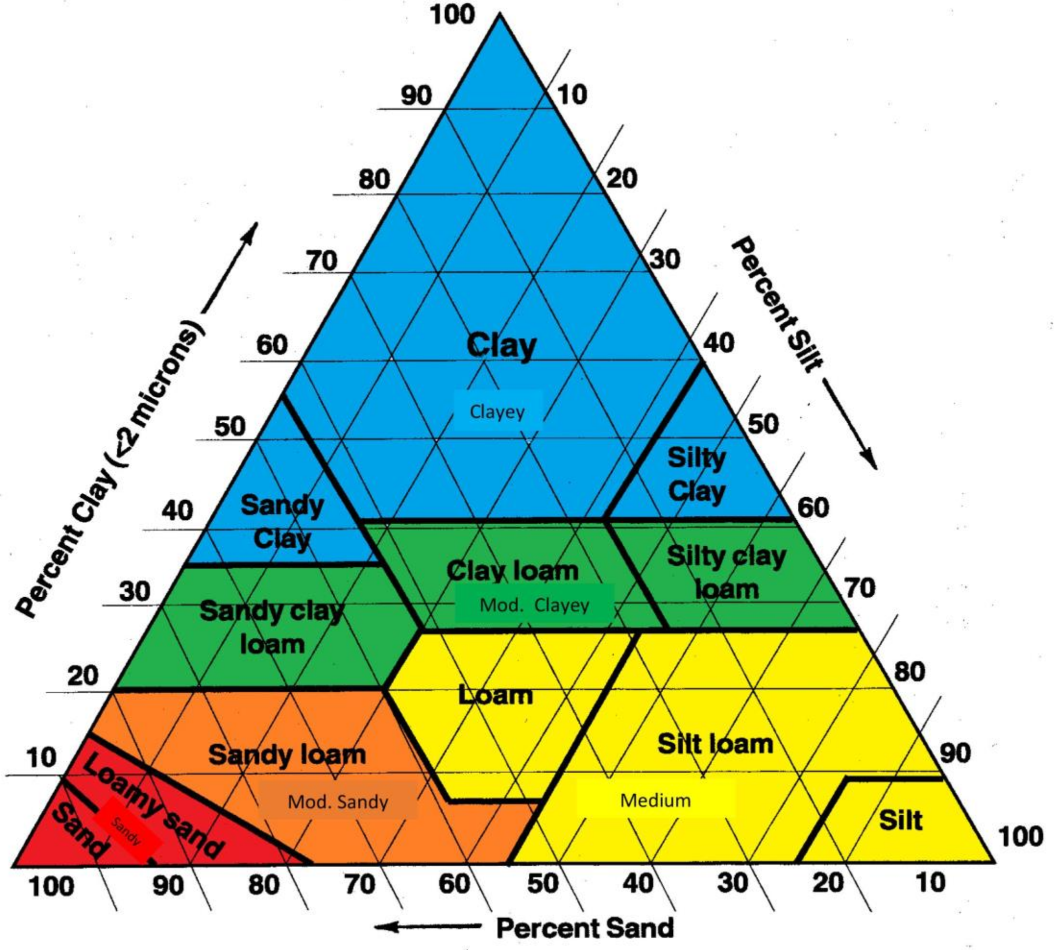


Soil Texture

- The relative percentages of sand, silt, and clay are what give soil its texture. A clay loam texture soil, for example, has nearly equal parts of sand, slit, and clay.
- Sandy topsoil has mostly large grains. Sandy soil packs together when it is wet, but crumbles as it dries out. Water drain through sandy soils quickly. Sandy soils are usually dry.
- Silty topsoil has medium sized grains and feels soft and velvety. It holds water well. That means water stays in or on top of the silt instead of draining through.
- Clay topsoil has very tiny grains that clump together. There is very little space between the grains, so water does not drain well through clay. Clay soil feels sticky when wet.
- **Loam** is a mixture of sand, silt and clay but also has lots of organic matter.

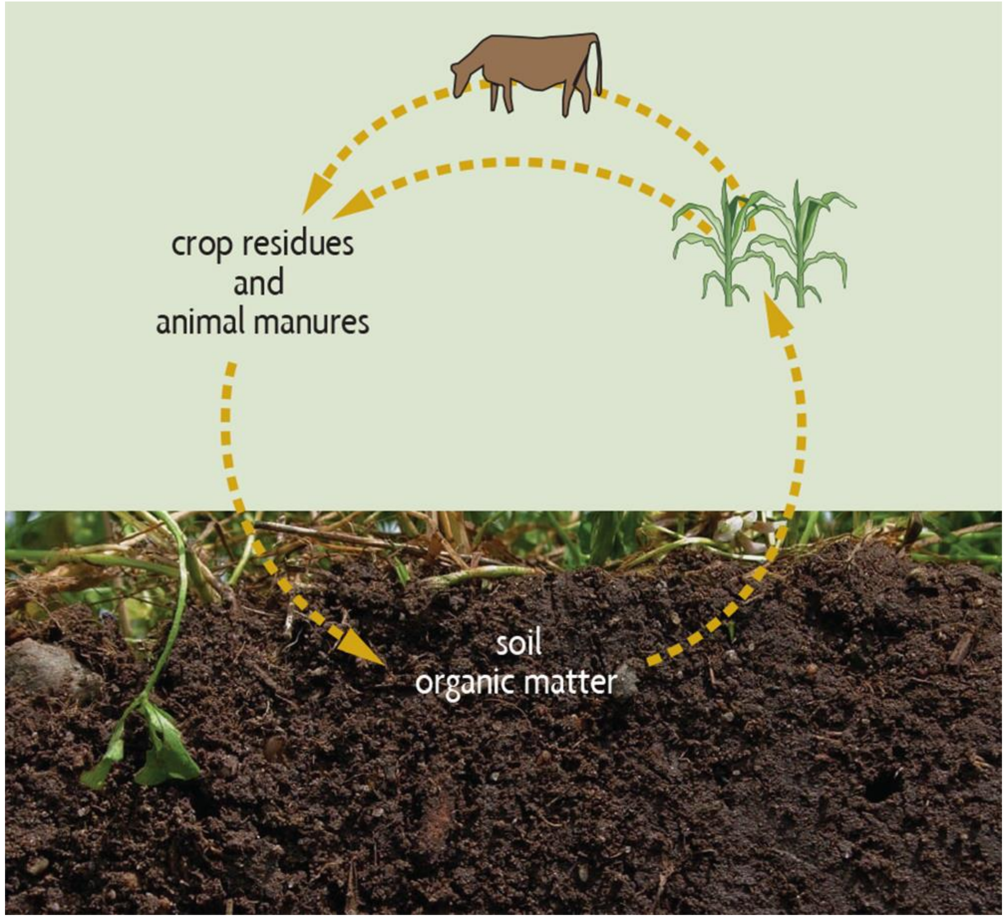
How do we determine soil texture?

- We use a soil triangle.
- The triangle is used so that terms like "clay" or "loam" always have the same meaning.
- There are 12 soil textural classes represented on the soil texture triangle.
- The texture classes are determined by measured percentages of sand, silt, or clay.



Organic: Organic Matter and Humus

- Organic matter comes from living materials that fix and store carbon and deliver it as a source of energy to the soil.
- Active organic matter consists of fresh plant and animal residues that take from a few months to a few years to decompose.
- **Humus** is a form of organic matter where decomposition has already completed and there is virtually no microbial activity.



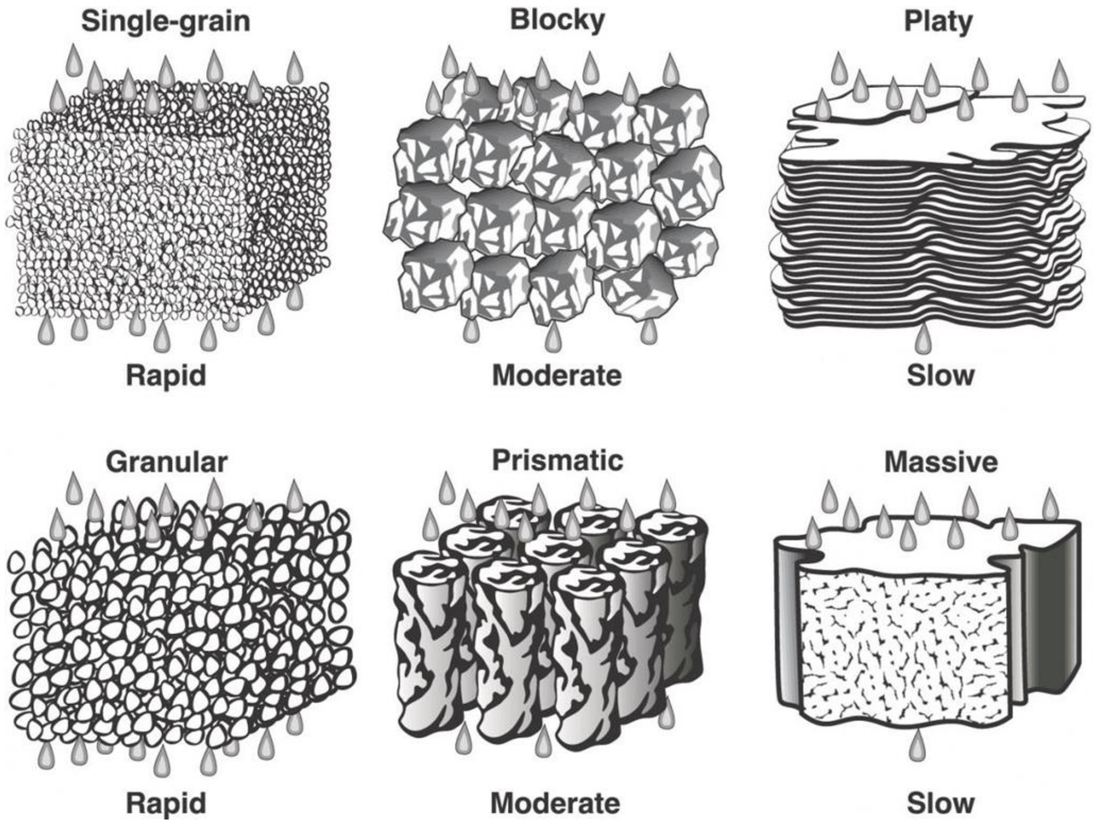
Why organic matter matters..

- Chemical: Soil organic matter significantly improves the soil's capacity to store and supply essential nutrients (such as nitrogen, phosphorus, potassium, calcium and magnesium), and to retain toxic elements. It allows the soil to cope with changes in soil acidity, and helps soil minerals to decompose faster.
- Physical: Soil organic matter improves soil structure. This ultimately helps to control soil erosion and improves water infiltration and water holding capacity, giving plant roots and soil organisms better living conditions.
- Biological: Soil organic matter is a primary source of carbon (C) which gives energy and nutrients to soil organisms. This supports soil functionality because it improves the activity of microorganisms in the soil and it can enhance biodiversity. Capturing carbon in the soil also lowers emissions of CO_2 to the atmosphere, and this mitigates climate change.

Soil Structure

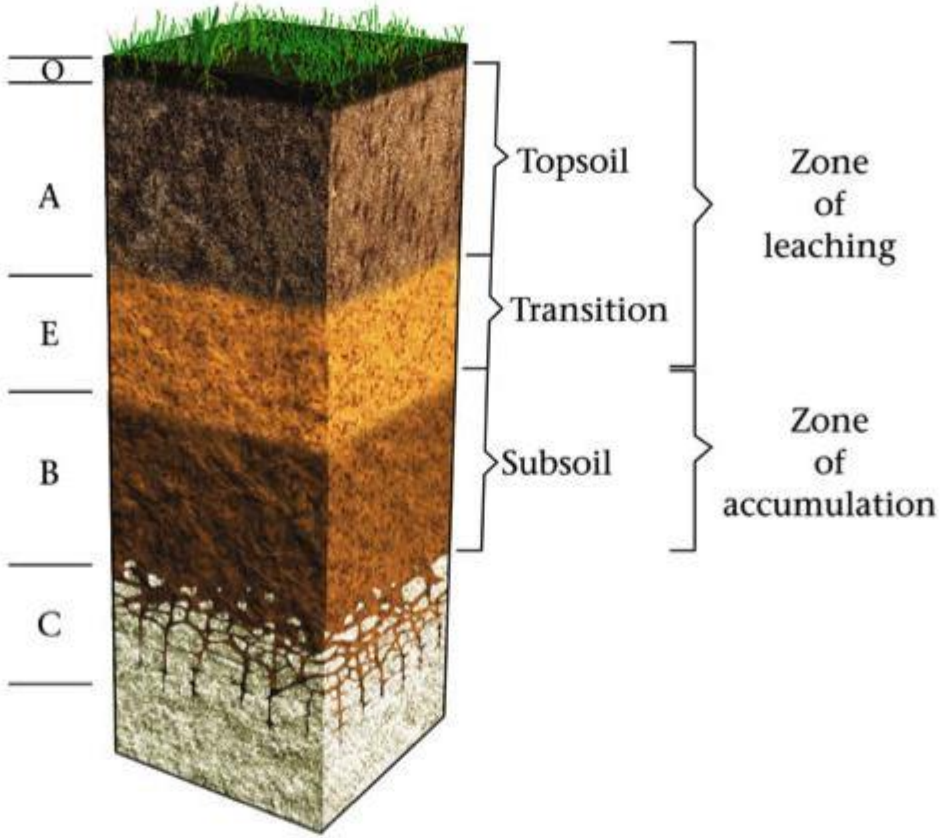
- Soil structure is the arrangement of soil particles into small clumps, called **peds** or **aggregates**.
- Depending on the composition and on the conditions in which the peds formed (getting wet and drying out, or freezing and thawing, foot traffic, farming, etc.), the ped has a specific shape.
- Soil structure can affect how well a soil can retain water or how well water can move through a soil profile.

Types of Soil Structure



Soil Profile

- Dig down deep into any soil, and you'll see that it is made of layers, or **horizons** (O, A, E, B, C, R). Put the horizons together, and they form a soil profile. Like a biography, each profile tells a story about the life of a soil.
  - **O** – (humus or organic) Mostly organic matter such as decomposing leaves. The O horizon is thin in some soils, thick in others, and not present at all in others.
  - **A** - (topsoil) Mostly minerals from parent material with organic matter incorporated. A good material for plants and other organisms to live.
  - **E** – (eluviated) Leached of clay, minerals, and organic matter, leaving a concentration of sand and silt particles of quartz or other resistant materials – missing in some soils but often found in older soils and forest soils.
  - **B** – (subsoil) Rich in minerals that leached (moved down) from the A or E horizons and accumulated here.
  - **C** – (parent material) The deposit at Earth's surface from which the soil developed.
  - **R** – (bedrock) A mass of rock such as granite, basalt, quartzite, limestone or sandstone that forms the parent material for some soils – if the bedrock is close enough to the surface to weather. This is not soil and is located under the C horizon.



Air & Water

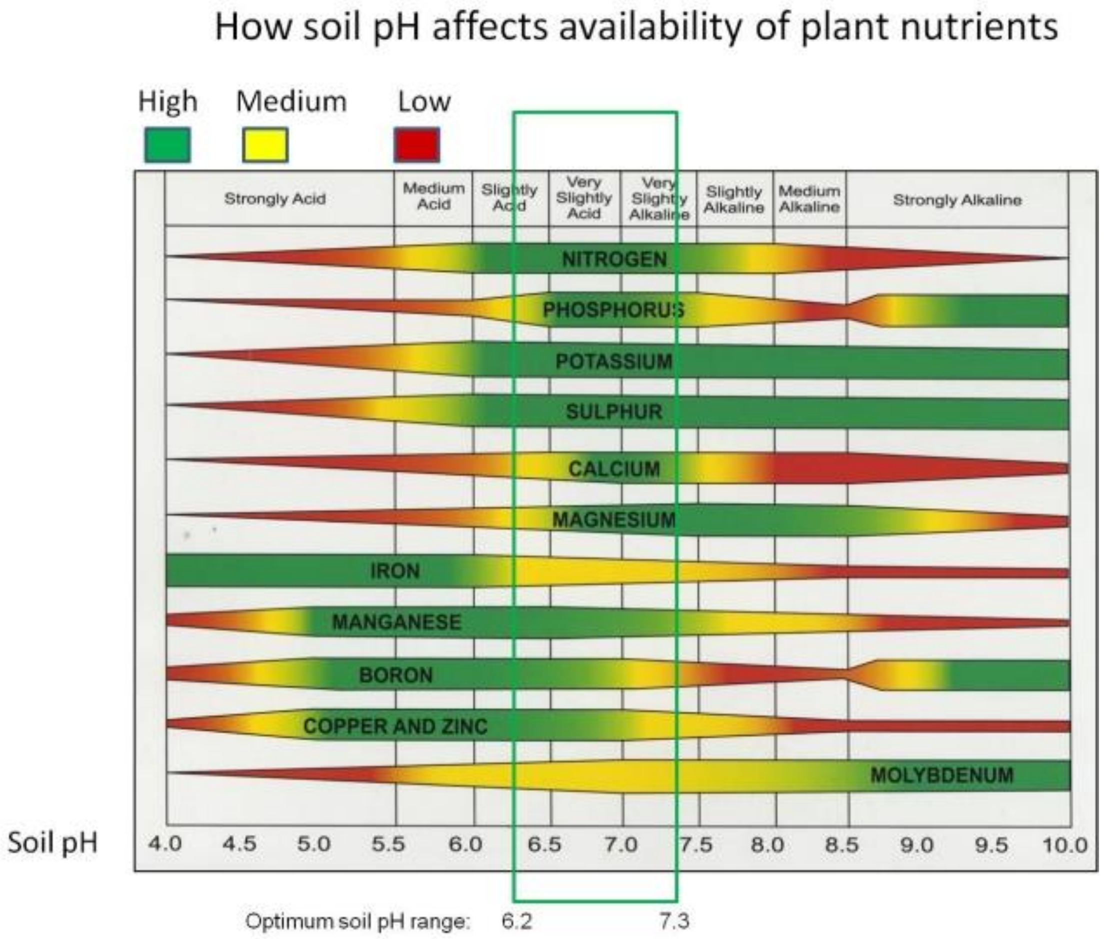
- Soil aeration influences the availability of many nutrients. Particularly, soil air is needed by many of the microorganisms that release plant nutrients to the soil. An appropriate balance between soil air and soil water must be maintained since soil air is displaced by soil water.
- An increase in soil water content often causes a reduction in soil aeration and vice versa.
- Soil water, sometimes referred to as the **soil solution**, contains dissolved organic and inorganic substances and transports dissolved nutrients, such as nitrogen, phosphorus, potassium, and calcium, to the plant roots for absorption.

Nutrients

- Soil is a major source of nutrients needed by plants for growth. To be able to grow, develop, and produce at their best, plants must have specific elements or compounds called plant essential nutrients.
- Primary nutrients, also known as **macronutrients**, are those usually required in the largest amounts.
  - **Carbon**, **hydrogen**, and **oxygen** are used in the highest amounts for plant structure
  - But the three main nutrients used for development are **nitrogen** (N), **phosphorus** (P) and **potassium** (K). Together they make up the trio known as NPK.
- Secondary nutrients are those usually needed in moderate amounts compared to the primary essential nutrients.
  - The secondary nutrients are calcium, magnesium, and sulfur.
- Micro- or **trace nutrients** are required in tiny amounts compared to primary or secondary nutrients.
  - Micronutrients are boron, chlorine, copper, iron, manganese, molybdenum, and zinc.

pH

- pH is an indication of the acidity or alkalinity of a soil and is measured in pH units.
- The pH scale goes from 0 to 14 with pH 7 as the neutral point.
- A pH of < 7 is acidic while a pH > 7 is alkaline.
- pH is influenced by the concentration of hydrogen ions.
- Soil pH influences the availability of many nutrients, therefore is essential to monitor so that plants do not become deficient.



Steps in Soil Sampling

Recommendations about when and how to apply nutrients are only as good as the soil sample submitted for analysis.

To obtain a representative soil sample, the following steps are useful: identify sampling locations (zones), determine the sampling depths, use the right sampling tools, sample at the right time, and handle the samples accordingly.

1. Sampling Locations

Map out the area where the plants are to be grown or are presently growing. This will help in record keeping and ensure that the soil is taken from throughout the entire area.

Divide the area such that each soil sample represents one plant type or condition. An area that has been divided according to obvious differences in plant types, plant performance, soil types, and drainage is shown in Figure 1.

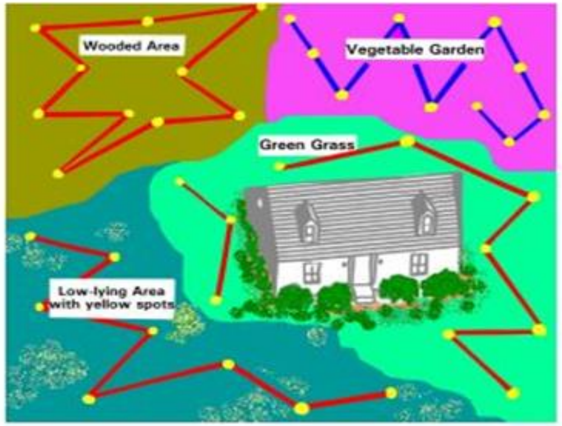


Figure 1. Area divided according to vegetation and soil characteristics. Yellow dots indicate sampling points.

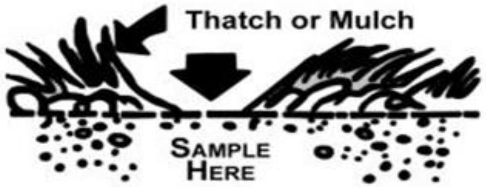


Figure 2. Remove grass thatch or mulch before sampling.

- Use a zigzag approach when taking samples. Collect 8-10 soil samples from each location (zone) as shown in Figure 1.
- For trees and shrubs, take soil samples from six to eight spots around the drip-line of the plants.

2. Sampling Depth

The depth of sampling depends on the type of plants being grown.

- For lawns, sample to a depth of 4 inches.
- For gardens, ornamentals, mixed fruit trees and wildlife plots, sample to a depth of 6 inches.

3. Sampling Time

Soil sampling should be done well in advance of planting or spring green-up. This allows adequate time for sample analysis, data interpretation, and fertilizer and lime application.

4. Sampling Tools

Use clean sampling tools and containers to avoid contaminating the soil sample. Never use tools or containers that have been used for fertilizer or lime. Collect samples with tools like trowels, shovels, spades, hand probes or hand augers.

Figure 3. Soil sampling with a trowel.

5. Sampling Procedures

Clear the ground surface of grass thatch or mulch (Figure 2). Using a trowel, push the tool to the desired depth into the soil. Push the handle forward, with the spade still in the soil to make a wide opening. Then, as shown in Figure 3, cut a thin slice from the side of the opening that is of uniform thickness, approximately 1/4-inch thick and 2 inches in width, extending from the top of the ground to the depth of the cut. Collect from several locations. Combine and mix them in a plastic bucket to avoid metal contamination. Take about a pint of the mixed soil and place it the UGA soil sample bag. Be sure to identify the sample clearly on the bag and the submission form before mailing.

Sample Handling

Samples should be air dried overnight. Dry samples on a flat surface lined with clean white paper. Take care to avoid contamination. After drying, transfer the sample to the soil sample bag and bring it to your local extension office. Your extension office will send samples to:

The Soil, Plant and Water Lab
University of Georgia
2400 College Station Road
Athens, GA 30602-9105

What does a soil scientist do?

- Soil scientists work for federal and state governments, universities, and the private sector. The job of a soil scientist includes collection of soil data, consultation, investigation, evaluation, interpretation, planning or inspection relating to soil science.
- A soil scientist needs good observation skills to be able to analyze and determine the characteristics of different types of soils.
- Computer skills and geographic information systems help the scientist to analyze the multiple facets of geomorphology, topography, vegetation, and climate to discover the patterns left on the landscape.
- Soil scientists work in both the office and field. They work in a variety of activities that apply soil science knowledge. This work is often done with non-soil science professionals.

What are the positions held?

- Wetland specialist
- Watershed technician
- Environmental technician
- State soil and water quality specialist
- Soil Conservationist
- County Agricultural Agent
- Crop consultant
- Soil scientist
- Research technician
- Crop production specialist
- Research scientist
- Farmer
- Landscaper

What kind of people become soil scientist?

- People who:
  - Love science
  - Enjoy working outdoors
  - Have enthusiasm for maps and relationships in nature
  - Are willingness to communicate their knowledge about soils and the environment to all aspects of society
  - Have a hunger for answers to questions and solutions to problems in agricultural and environmental settings
  - Have a desire to contribute to the success of others

How do people become soil scientist?

- Most soil scientists have earned at least a bachelor degree from a major agricultural university.
- At many universities, two choices are available for specialized training in soils.
    - The Soil Science option prepares students to enter the agricultural sector as farm advisors, crop consultants, soil and water conservationists, or as representatives of agricultural companies.
    - The Environmental Science option prepares soil scientists for careers in environmental positions dealing with water quality concerns, remediation of contaminants or for on-site evaluation of soil properties in construction, waste disposal, or recreational facilities.