

TOPIC 4.2 TO 4.3

SOIL FORMATION, EROSION, COMPOSITION, AND PROPERTIES

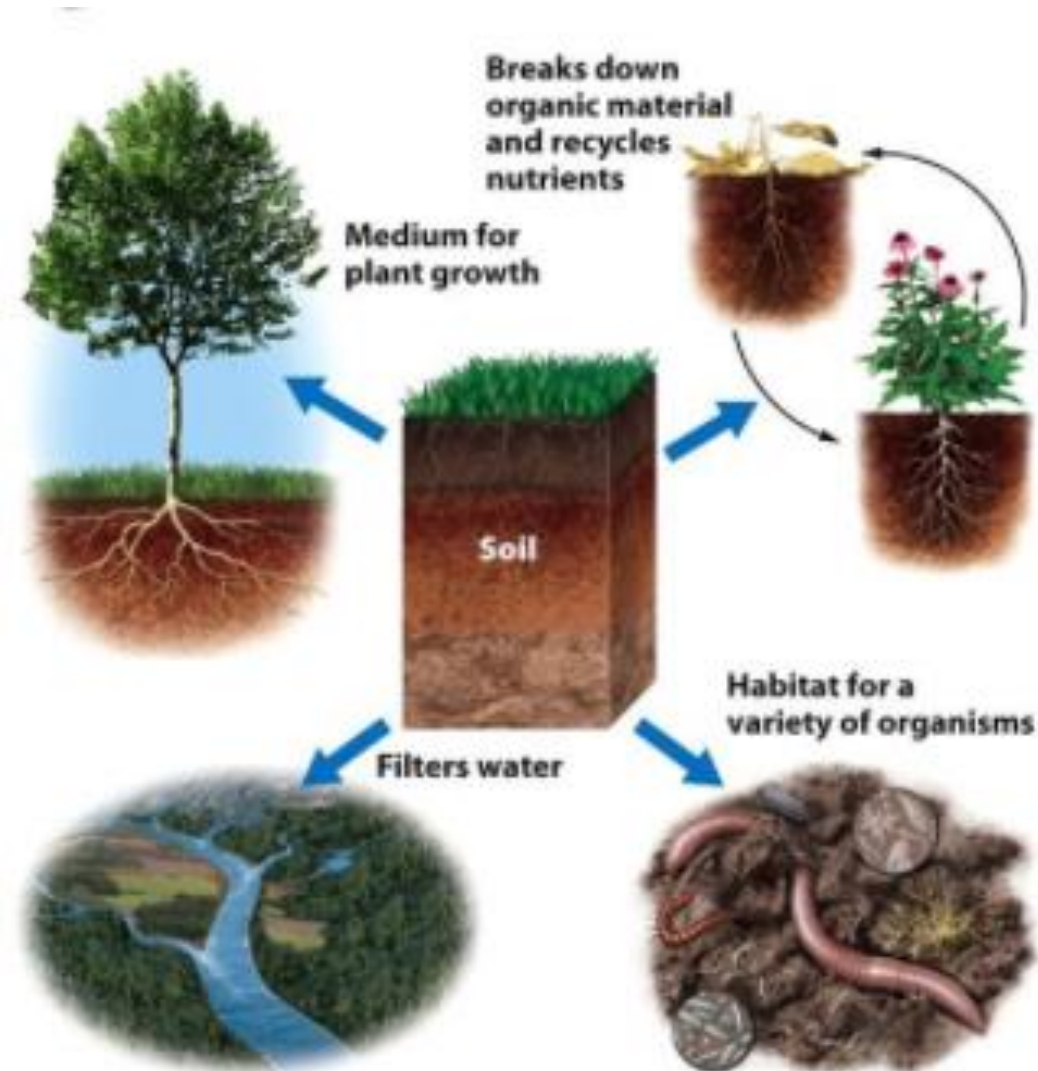
Enduring Understanding: Earth's systems interact, resulting in a state of balance over time.

Learning Objectives: Describe the characteristics and formation of soil. Describe similarities and differences between properties of different soil types.

Related Readings: pg. 214-221, "Environment; The Science Behind The Stories" 4th edition Withgott, Jay and Laposata, Matthew.

What is Soil?

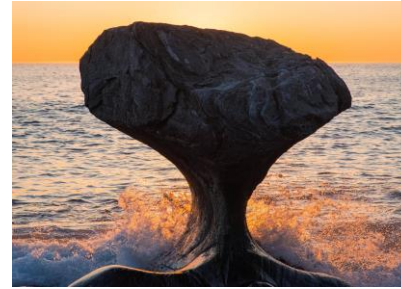
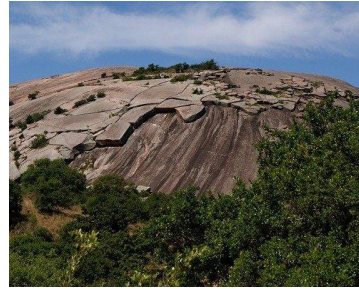
- Mix of inorganic (geologic) and organic components.
 - **Weathered rock and mineral particles** (sand, silt, and clay)
 - **Nutrients** (NO_3^- , NH_3 / NH_4^+ , PO_4^{3-} , Ca^{2+} K^+ , etc)
 - **Humus** (partial decomposed biomass and organic waste materials)
 - **Pore spaces** containing water and air
 - **Living organisms** (mammals, insects, earthworms, fungi, protists, bacteria)



Ecosystem Services of Soil

- **Anchors plant roots**, provides the nutrients, water, shelter needed for growth.
- **Filters rainwater**, trapping pollutants in pore spaces and plant roots. Clean water enters aquifers.
- Key reservoir in all major **nutrient cycles**.
- **Provides habitat** for soil organisms

Soil Formation



- **Weathering**

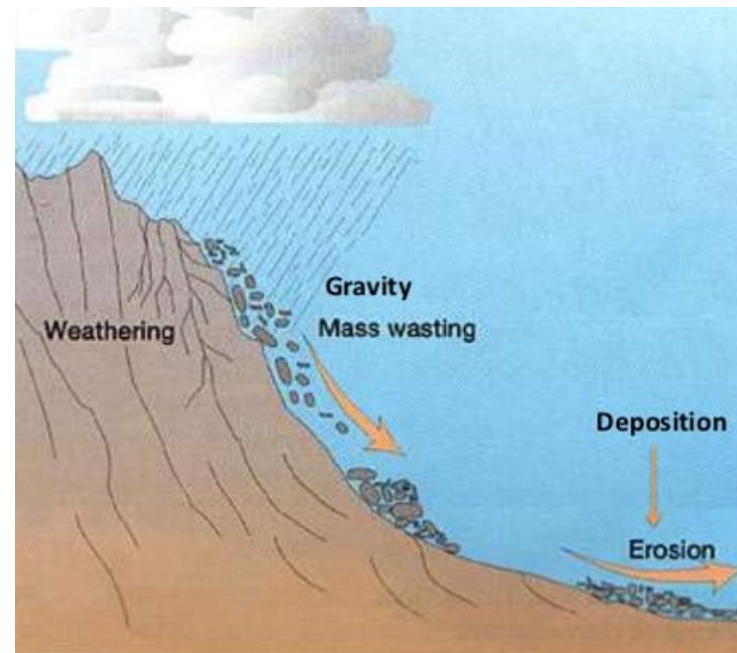
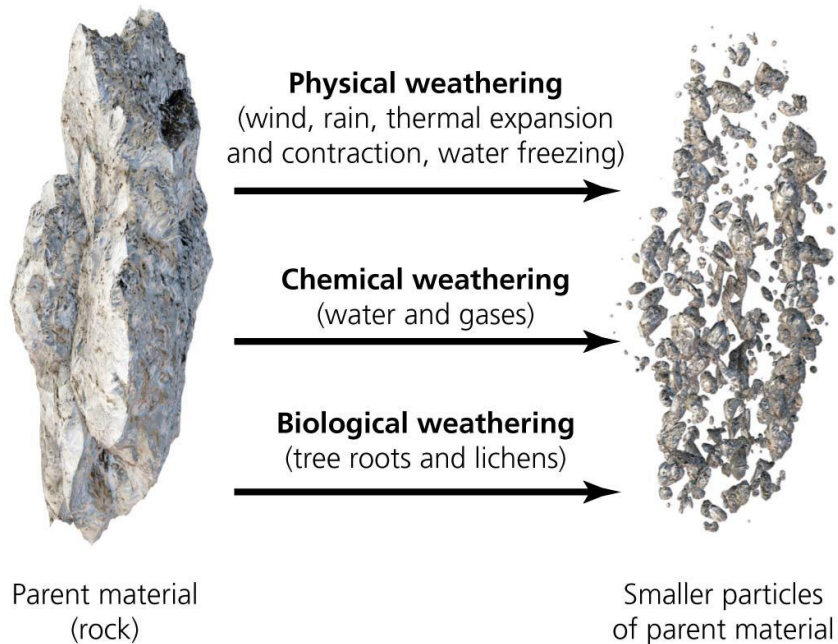
- Breakdown of **parent material** (bed rock, smaller rock, minerals, and sediments) into smaller pieces

- **Erosion**

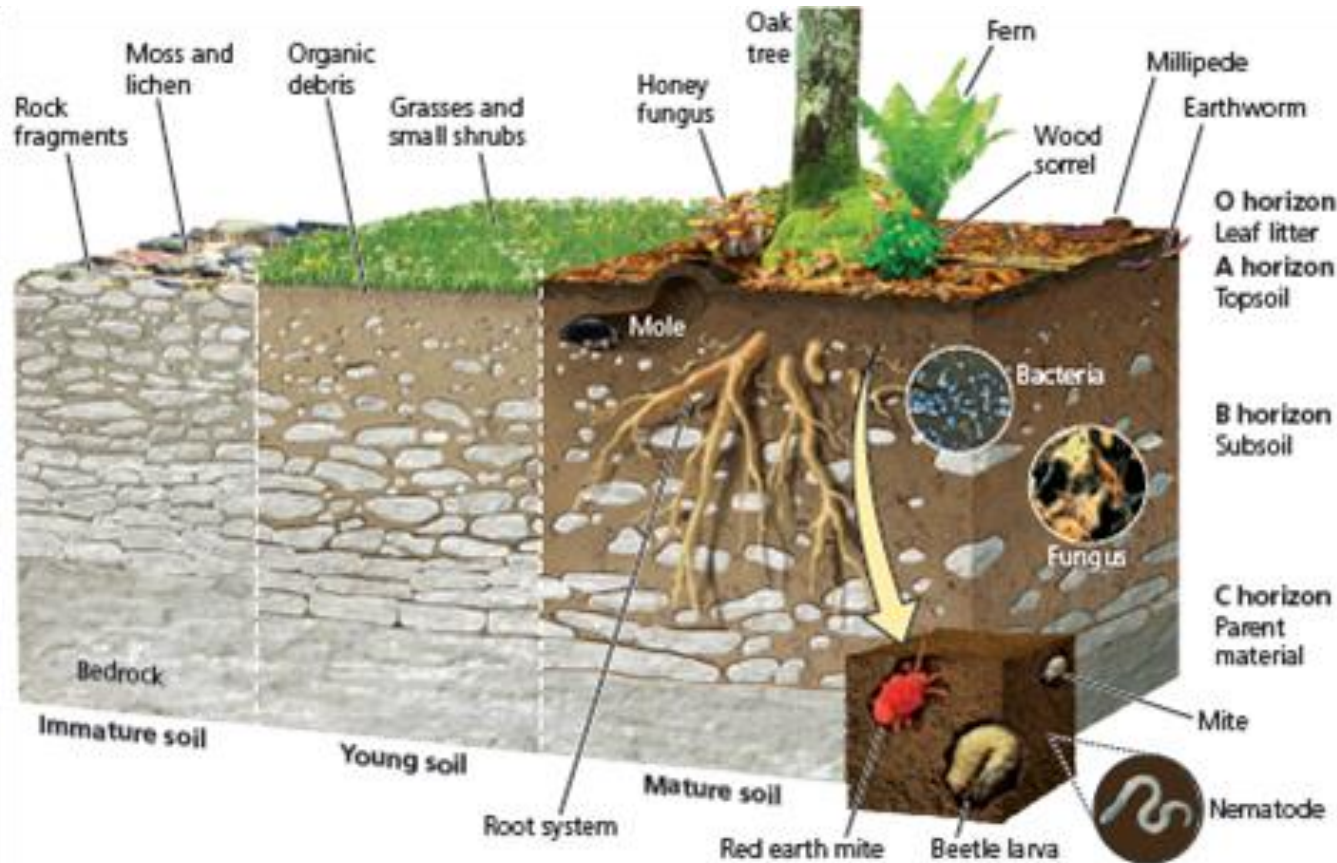
- Transport and **deposition** of weathered parent material by wind, water, and gravity mass wasting events.

- **Decomposition**

- The breakdown, by physical and biological mechanisms, of organic substances found in the soil.



Factors Affecting Soil Formation



- The weathering of parent material and the accumulation and transformation of organic matter are influenced by the following factors:

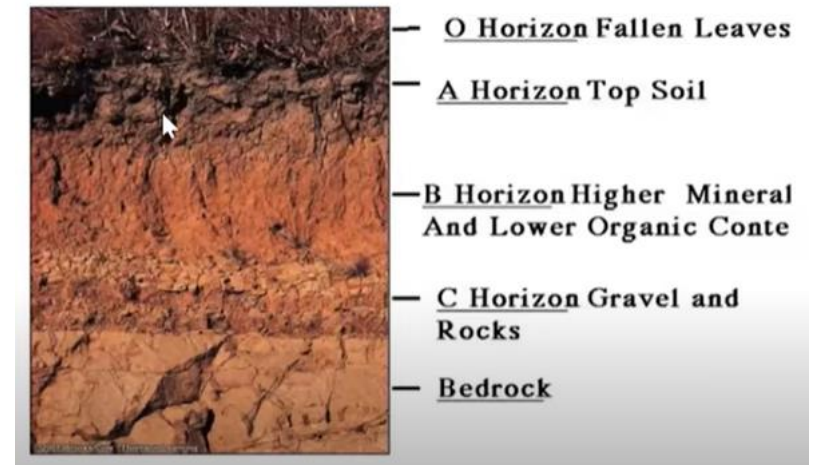
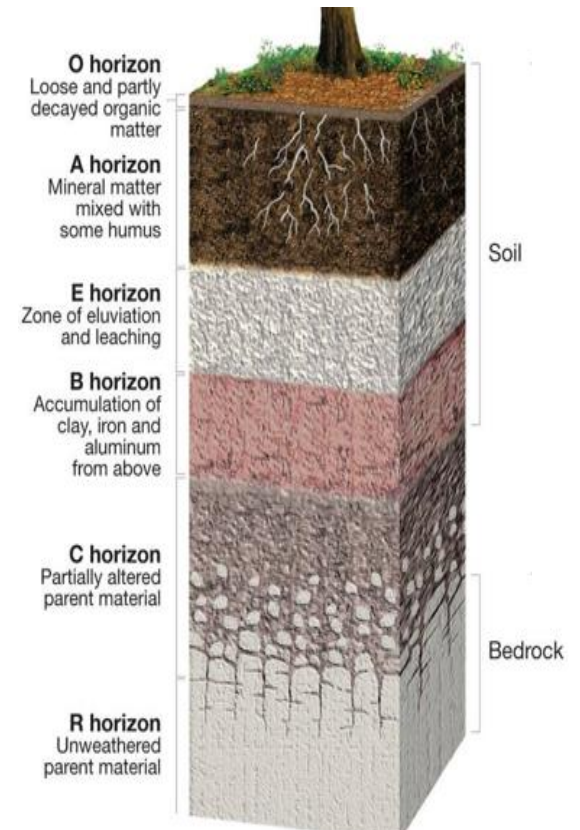
- *Climate*: soils form faster in warm, wet climates.
- *Organisms*: plants and decomposers add organic matter (ex: deciduous forests and grasslands)
- *Topography*: hills and valleys affect exposure to sun, wind, and water which effect plant growth, weathering and erosion rates
- *Parent material*: influences rate of soil formation and properties of resulting soil, such as texture and nutrient content.
- *Time*: the depth of soil formed is dependent on the amount of time elapsed.

- **The rate of soil formation is highly variable, but generally very slow, approximately 1 cm per 200 years.**

Mature Soil Consists of Horizons

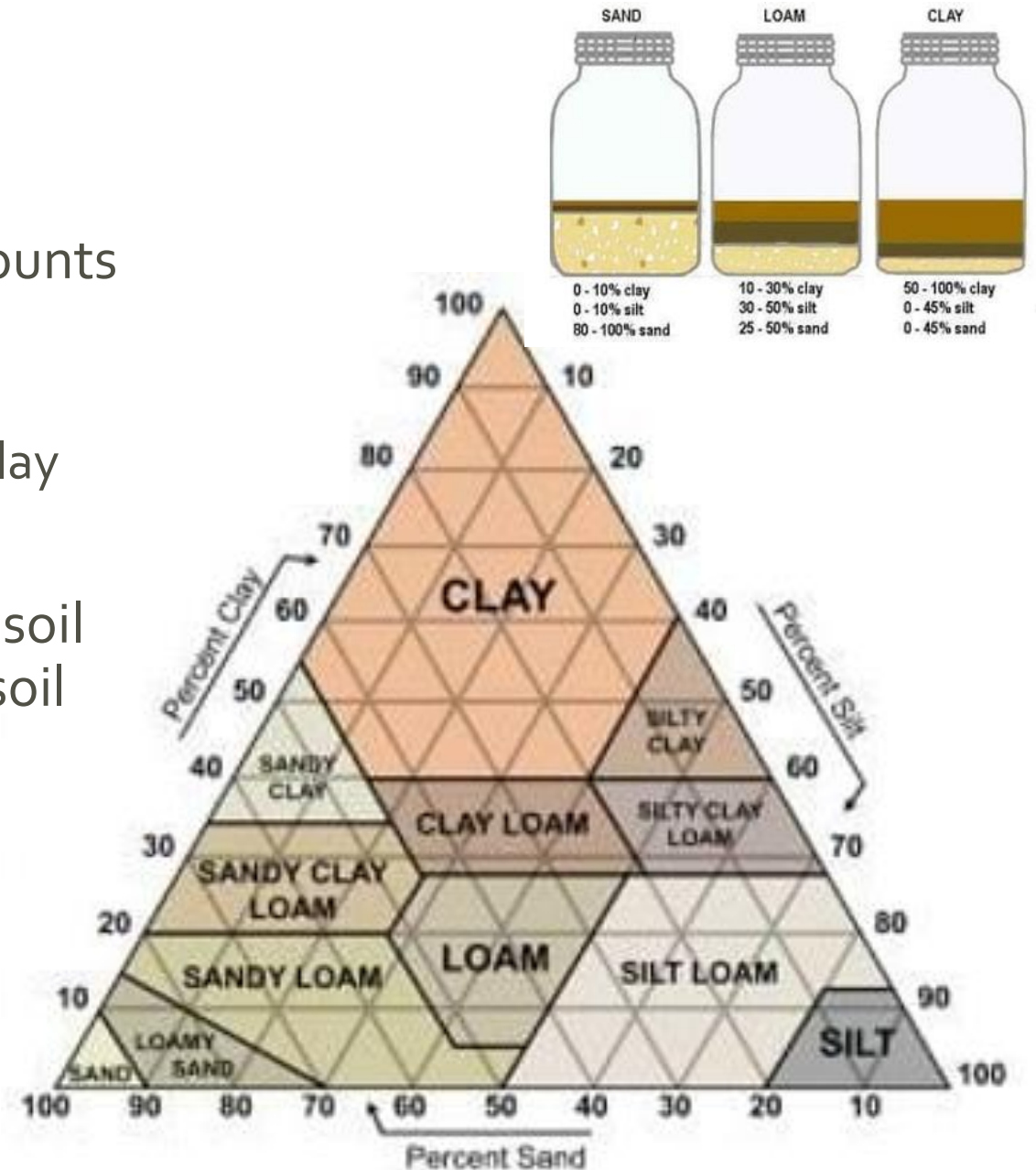
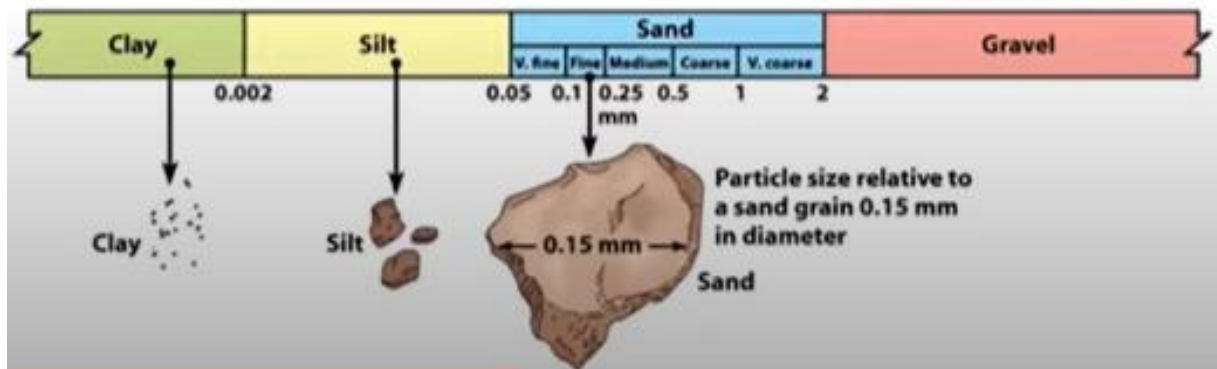
Soil formation proceeds from above and below the ground and result in layers, or horizons, with distinct appearances and characteristics.

- **O horizon:** Layer of organic matter on top (plant roots, fallen leaves woody debris, animal waste, humus, etc). Provides food to soil decomposers and reduces loss of water from the soil due to evaporation
- **A Horizon:** a.k.a topsoil. Contain humus and fine mineral materials (sand, silt, clay) Most biologically active layer of soil.
- **E Horizon:** Eluviated layer. Layer that has lost much of the nutrients and organic matter found in the A horizon due to leaching. Not always present.
- **B Horizon:** a.k.a the subsoil and Zone of Accumulation for leached material (clay, nutrients). Lighter layer, made up mostly of mineral matter (sand, silt, clay), with little organic material and some nutrients.
- **C Horizon:** Coarsely weathered parent material the has not been completely weathered into finer sediments



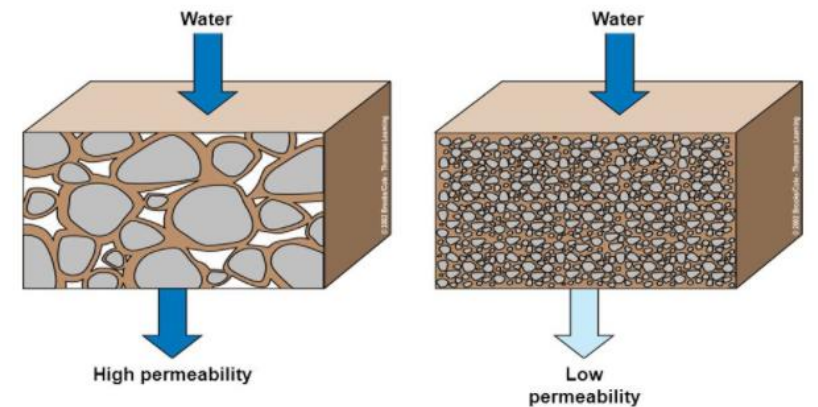
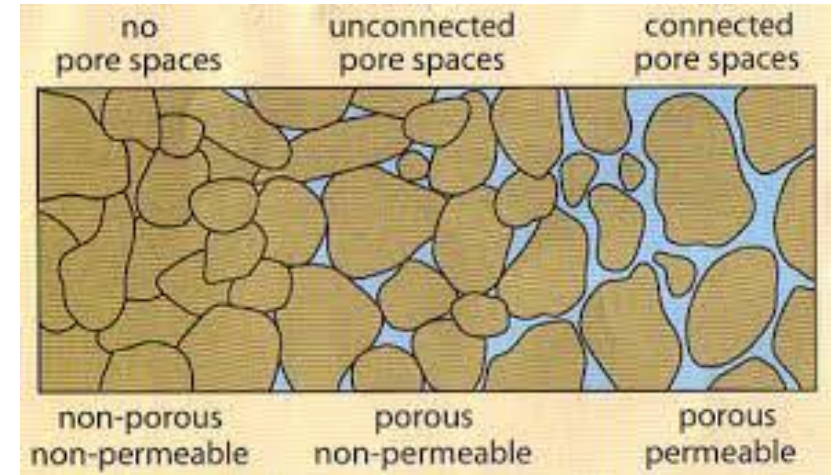
Soil Properties - Texture

- **Soil texture** is determined by the relative amounts of sand, silt, and clay in a soil sample.
 - **Loam** = mixture
 - Loamy soils contain a mixture of sand, silt and clay and are generally agriculturally productive
- The particle size and composition of soils and soil horizons can affect many other properties of soil including porosity, permeability, and fertility



Soil Properties – Porosity and Permeability

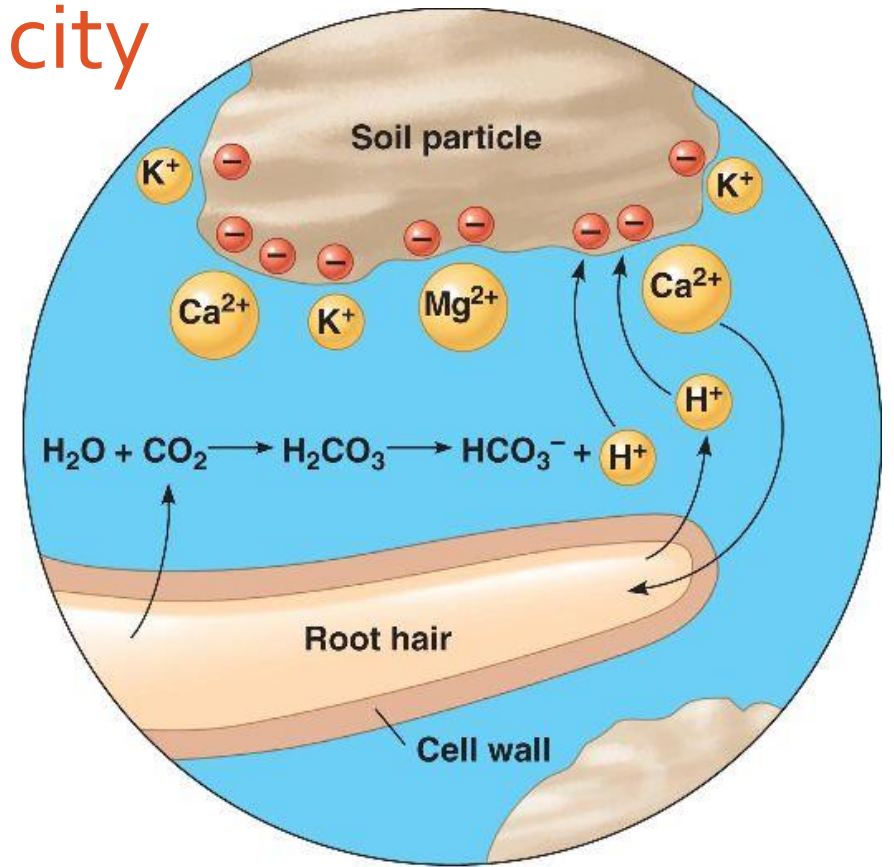
- **Soil porosity** is the amount of air space between mineral particles (sand, silt, clay) in the soil.
 - Porosity affects the ability of water and air to move through the soil, and it is related to the texture of the soil.
 - Larger soil particle grains (sands) can not pack together as tightly as smaller particle grains
 - Sandy soils tend to have the greatest volume of pore space, clay soils tend to have the least.
- **Soil permeability** is the rate that water moves through a soil sample.
 - Soil permeability is related to the volume of pore space in a soil.
 - If a soil is too permeable, water will drain through the root zone too rapidly to be useful to plants.
 - If soil is not permeable enough, root cells of plant can drown
 - they need to respire and exchange gases and therefore can not be constantly submerged.



Soil Properties – Cation Exchange Capacity

- **Cation exchange**

- Decomposers release nutrients into the soil from decomposition of organic matter.
- Many plant nutrients form cations (K^+ , Mg^{2+} , Ca^{2+}) which bind to negatively charged mineral particles in soils.
- Plant roots contribute CO_2 (from cell respiration) to soils which reacts with H_2O to form H_2CO_3 which in turn dissociates into H^+ and CO_3^{2-}
- H^+ ions displace cations from soil particles and make them available for assimilation by plant roots.
- **Cation exchange capacity** is the capacity of soils to provide cations to plant roots. A common measure of soil fertility.
 - More organic matter means more cations.
 - Fine particles (clay) increase soil surface area and bind more cations.
 - Decreasing pH increases the H^+ concentration in soils.
 - Soil pH levels depend on parent material of the soil, pH of precipitation, and pollutants



Cation Exchange Capacity Explained

<https://www.youtube.com/watch?v=HmEyyGxOfI>

Conserving Soil

- Erosion is a problem in many ecosystems because it can occur faster than the processes that form soils.
 - Erosion removes topsoil, the most valuable soil layer for living organisms.
 - Windy areas with sparse plant cover experience the greatest effect from wind erosion.
 - Rainy areas with steep slopes and sparse vegetation suffer more water erosion.



3 Primary Ways Humans Make Soil More Vulnerable to Erosion

- Over-cultivating fields
- Grazing rangelands beyond carrying capacity
- Clearing forests with large clear-cuts

ROOTS MATTER!

- Vegetation is important for preventing erosion.
- Roots form dense mats that help resist wind and water erosion

