

Environmental Science

A Study of interrelationships

Unit 6

Soil and its Uses

Useful Words and Expressions

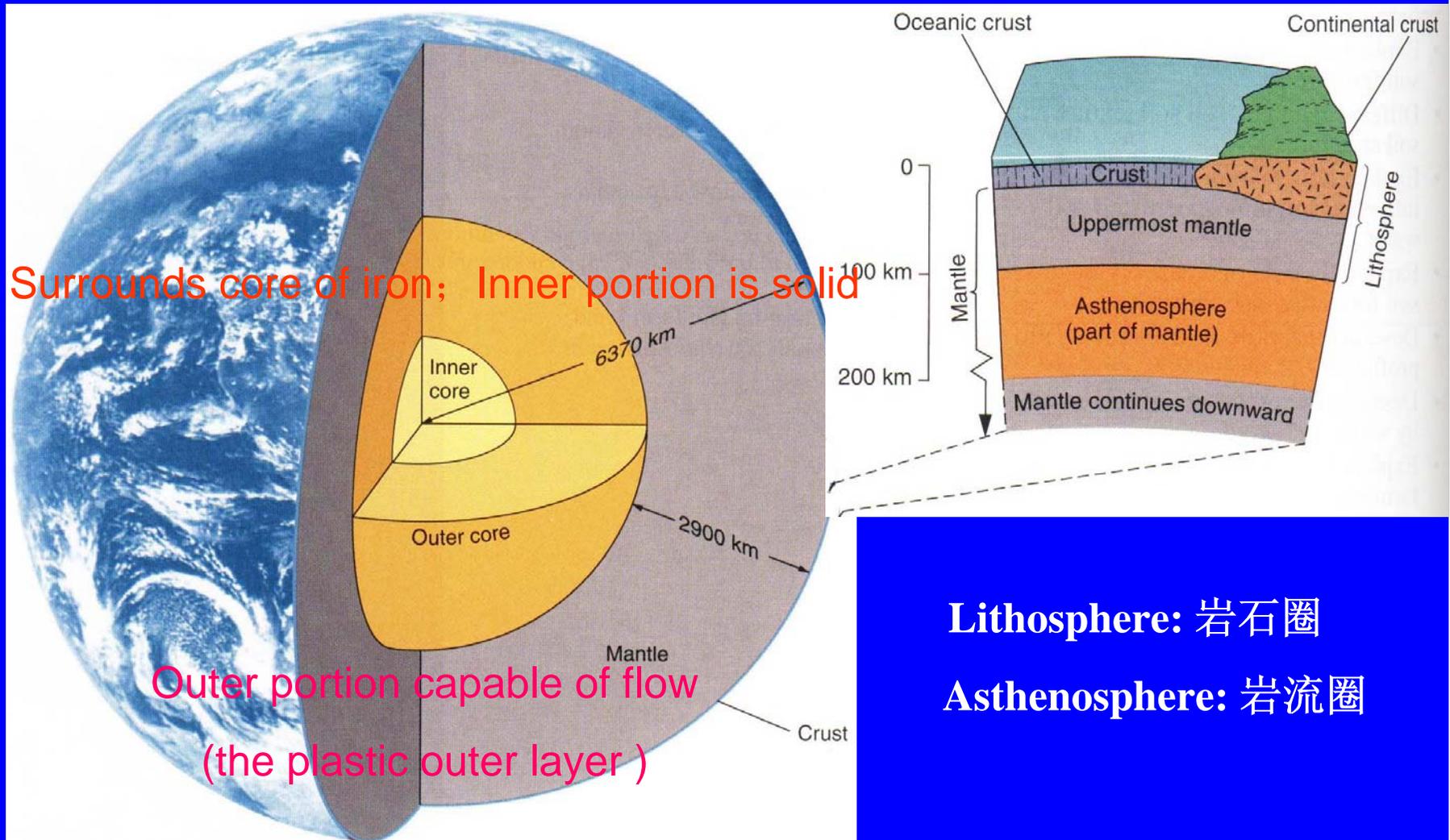
- Crust –地壳
- Mantle –地幔
- Lithosphere – 岩石圈
- Asthenosphere – 岩流圈
- Plate Tectonics – 板块构造学说
- Weathering – 风化
- Hydrolysis – 水解
- Lava –熔岩
- Parent material –原生材料

Useful Words and Expressions

- Humus – 腐殖质
- Soil profile – 土壤剖面
- Soil texture – 土壤构成
- Soil structure – 土壤结构
- Soil erosion – 土壤侵蚀
- Contour farming – 仿地形耕种
- Strip farming – 间耕
- Soil conservation practices – 水土保持

Geologic Processes (地质学过程)

- **Crust (地壳)** - Extremely thin, less-dense soil.
- **Mantle (地幔)** - Makes up majority of earth.

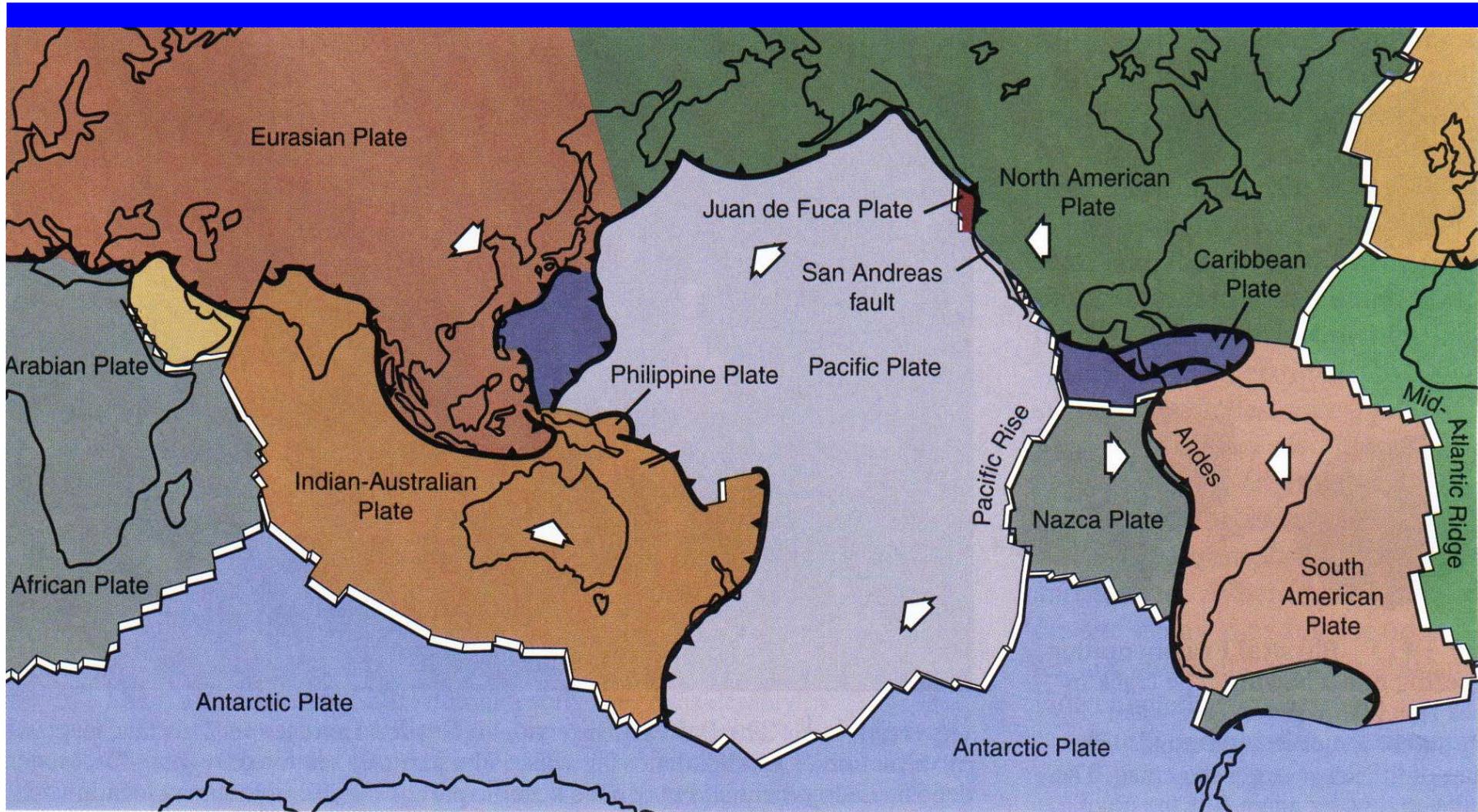


Lithosphere: 岩石圈

Asthenosphere: 岩流圈

Geologic Processes

- **Plate Tectonics** (板块构造学说) - is the concept that the outer surface of the Earth consist of large plates composed of the crust and the outer portion of the mantle (lithosphere) and that these plates are slowly moving over the surface of the liquid outer mantle.
 - Heat from earth core causes movement.
 - ❖ Plates are pulling apart in some areas, and colliding in others due to the fact that the movements of the plates on this plastic outer layer of the mantle are independent of each other.
 - Building processes counteracted by processes tending to tear down land.



 Direction of plate motion

 Subduction zone
(sawteeth point toward
overriding plate)

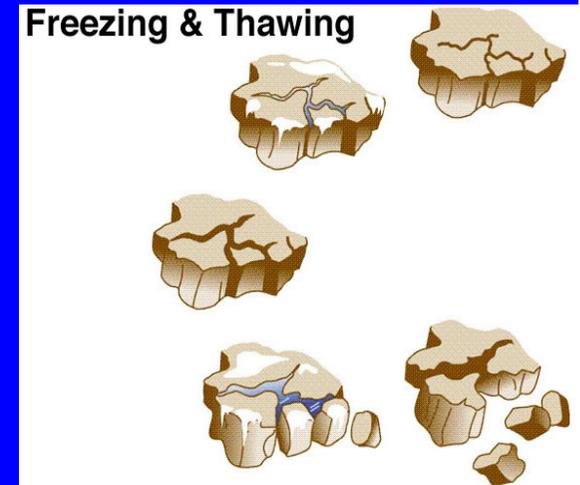
 Spreading ridge
 Transform fault

Weathering

- **Weathering** - Factors bringing about fragmentation or chemical change of parent material (reducing the size of the particle).
 - **Mechanical weathering**
 - **Chemical weathering**

Mechanical weathering- Results from physical forces reducing size of rock particles without changing the chemical nature of the rock

- temperature changes
- abrasion of rock particles (caused by force that move and rub rock particles against each other)
- wind and moving water also move small particles and deposit them at new location,exposing new surface to the weathering process



Chemical weathering- chemical weathering involves the chemical alteration of the rock in such a manner that it is more likely to fragment or to be dissolved

- some small rock fragment may combine with oxygen from the air (when it was exposed to the atmosphere) and chemically change to different compounds.
- some small rock may combine with water molecules (hydrolysis)
- the oxidized or hydrolyzed molecules are more readily soluble in water and, therefore, may be removed by rain or moving water.

氧化态或水解态岩石分子更易于在水中溶解，因此，它们可随降雨或水流而迁移。

Soil and Land

- **Land** - Portion of world not covered by water.
- **Soil** – a thin covering over the land consisting mixture of minerals, organic material, living organisms, air, and water.
- **Soil formation** – a combination of physical, chemical and biological process over time
 - the soil building begins with the fragmentation of the parent material
 - **Parent material** - ancient layers of rock, or more recent geologic deposits from lava (熔岩) flows or glacial activity

Soil Formation

Factors affecting soil formation –the kind and amount of soil developed depends on the following factors:

- the kind of parent material present (such as the size and chemical nature of the the particle)
- the climate (such as temperature) and time involved
- the slope of the land
- the role of the organisms: traps small particles ;releases chemicals (acid) causing further fragmentation and chemical breakdown of the rock particles;contributes to one of the soil components (such as humus) through their death and decay

生命体在土壤形成过程中的作用：网捕细小岩石颗粒；释放化学物质（特别是酸性化学物质）进一步使岩石颗粒破碎；在自身死亡和腐化后成为土壤的成分。

Humus – a kind of organic material resulting from the decay of plant and animal remains.

- It is a very important soil component that accumulates on the surface and ultimately becomes the component mixed with the top layers of rock particles, and supplies some of the needed nutrients to plants.
- Humus increase the water-holding capacity of soil.
- Humus increase the acidity of soil so that the inorganic nutrients become available to plants.
- Humus also tends to stick other soil particle together and helps to create crumbly soil which allows water absorption and permits air to be incorporated into soil (this helps the soils have more pore space).

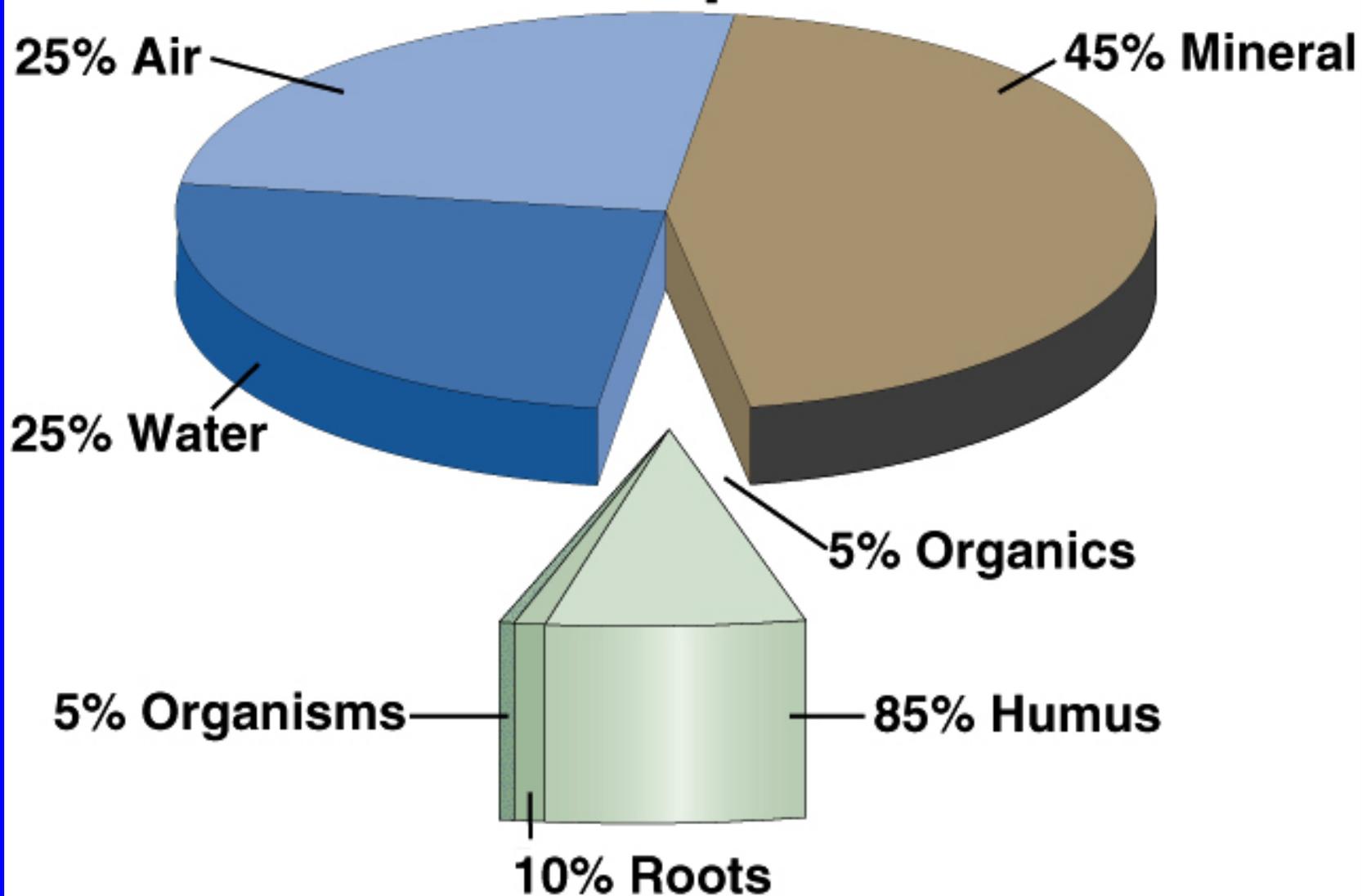
Other Factors Influencing Soil Formation:

- Burrowing animals (Earthworms): resulting further mixing of organic and inorganic material, which increases the amount of nutrients available for plant use; soil aeration and drainage are also improved
- Plant roots :release of organic matter and nutrients into soil and provide channels for water and air.
- Bacteria and Fungi :act as decomposers to break down organic material ;serve as important links in many mineral cycles;release nutrients

Other Factors Influencing Soil Formation:

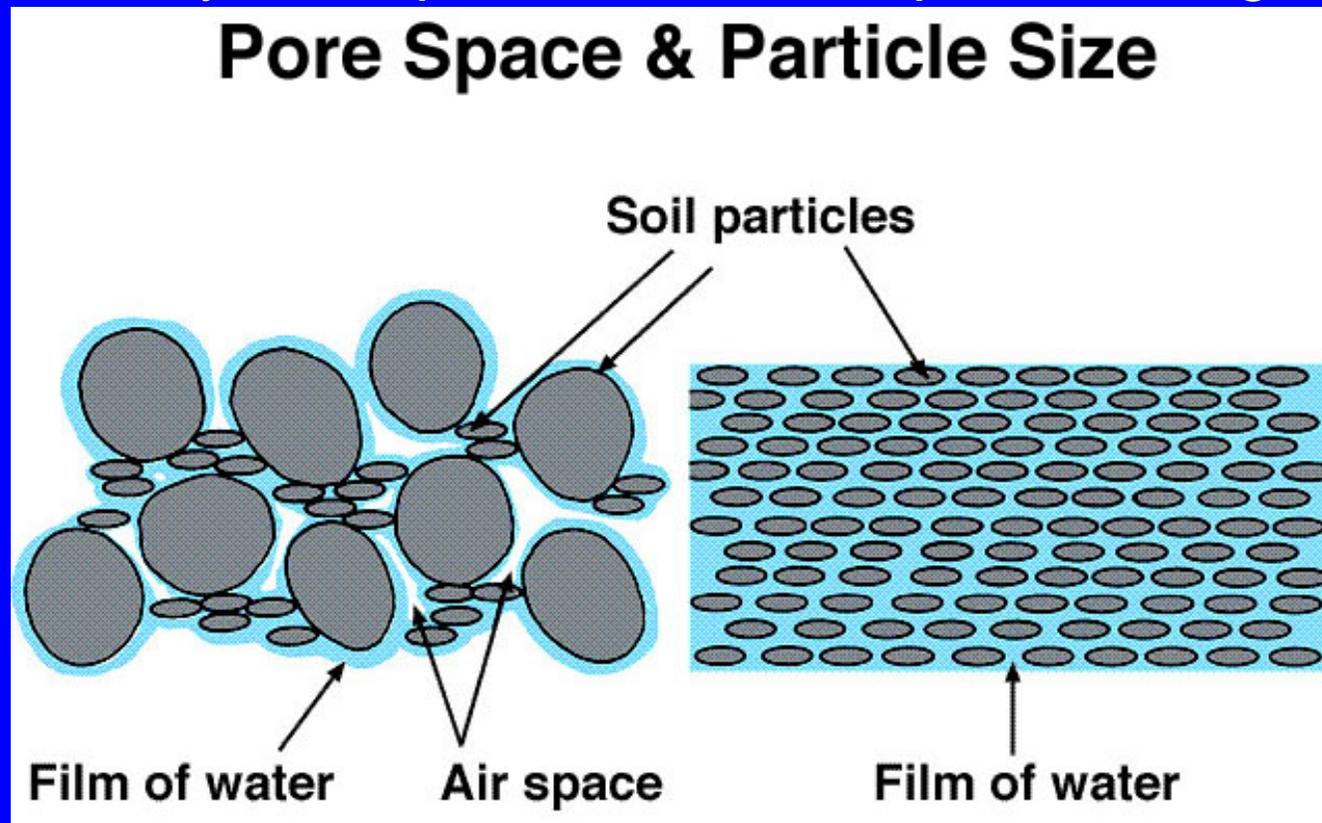
- Soil pH: affects the availability of nutrients—affects the kinds of plants that will grow — affects the amount of organic matter added to soil;
- The amount of rainfall: affects the amount of calcium, magnesium and potassium are leached from the soil

Soil Components



Soil Properties

- **Soil Texture** - Determined by the size of mineral particles within the soil.
 - Too many large particles leads to extreme leaching.
 - Too many small particles leads to poor drainage.

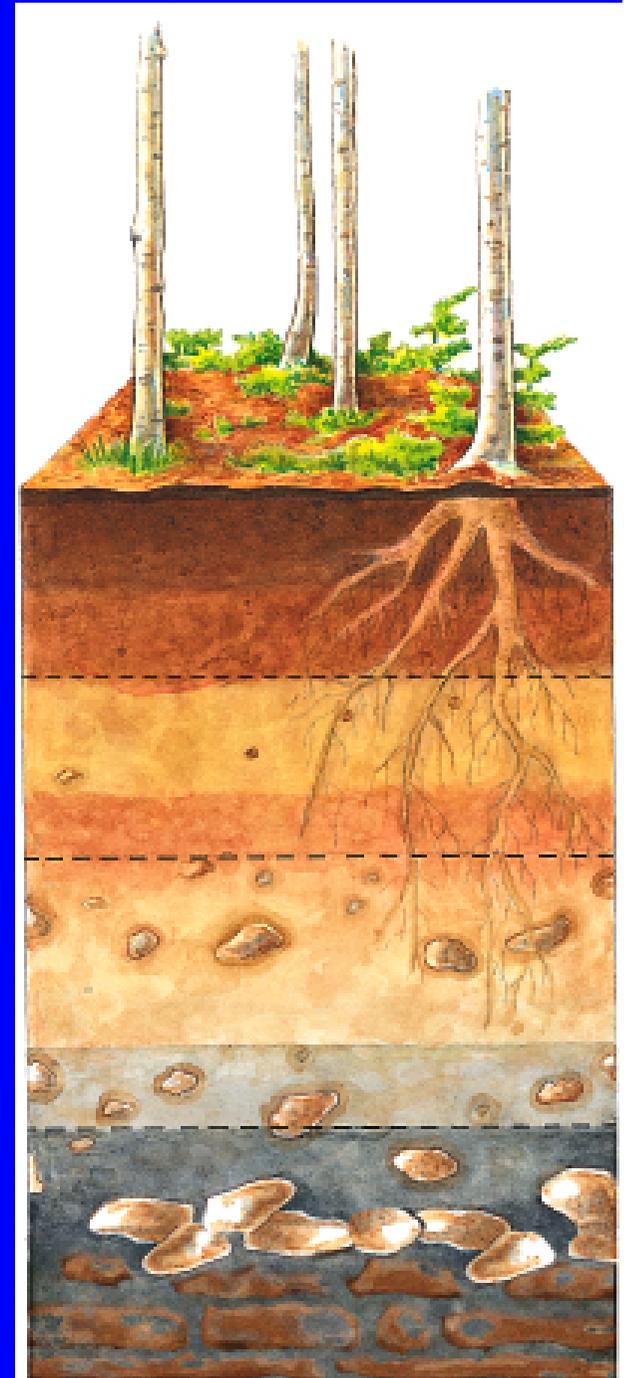


Soil Properties

- **Soil Structure** - Refers to the way various soil particles clump together.
 - In good soils 2/3 of the intra-soil spaces contain air after the excess water has drained.
 - The earthworms, insects, algae, bacteria, and fungi are typical inhabitants of soil.

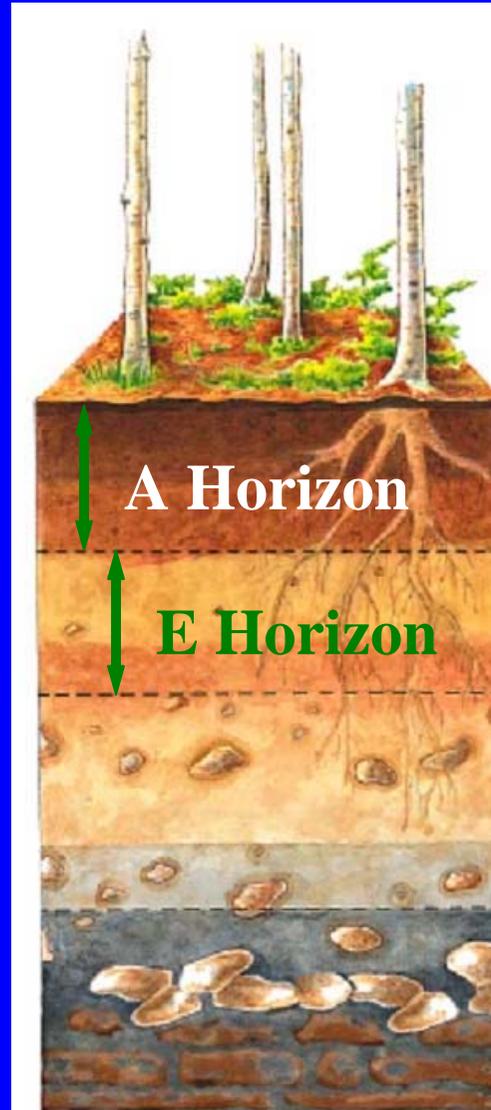
Soil Profile

- **Soil Profile** - A series of horizontal layers of different chemical composition, physical properties, particle size, and amount of organic matter.
- **Horizon** - Each recognizable layer of the profile.



Soil Horizons

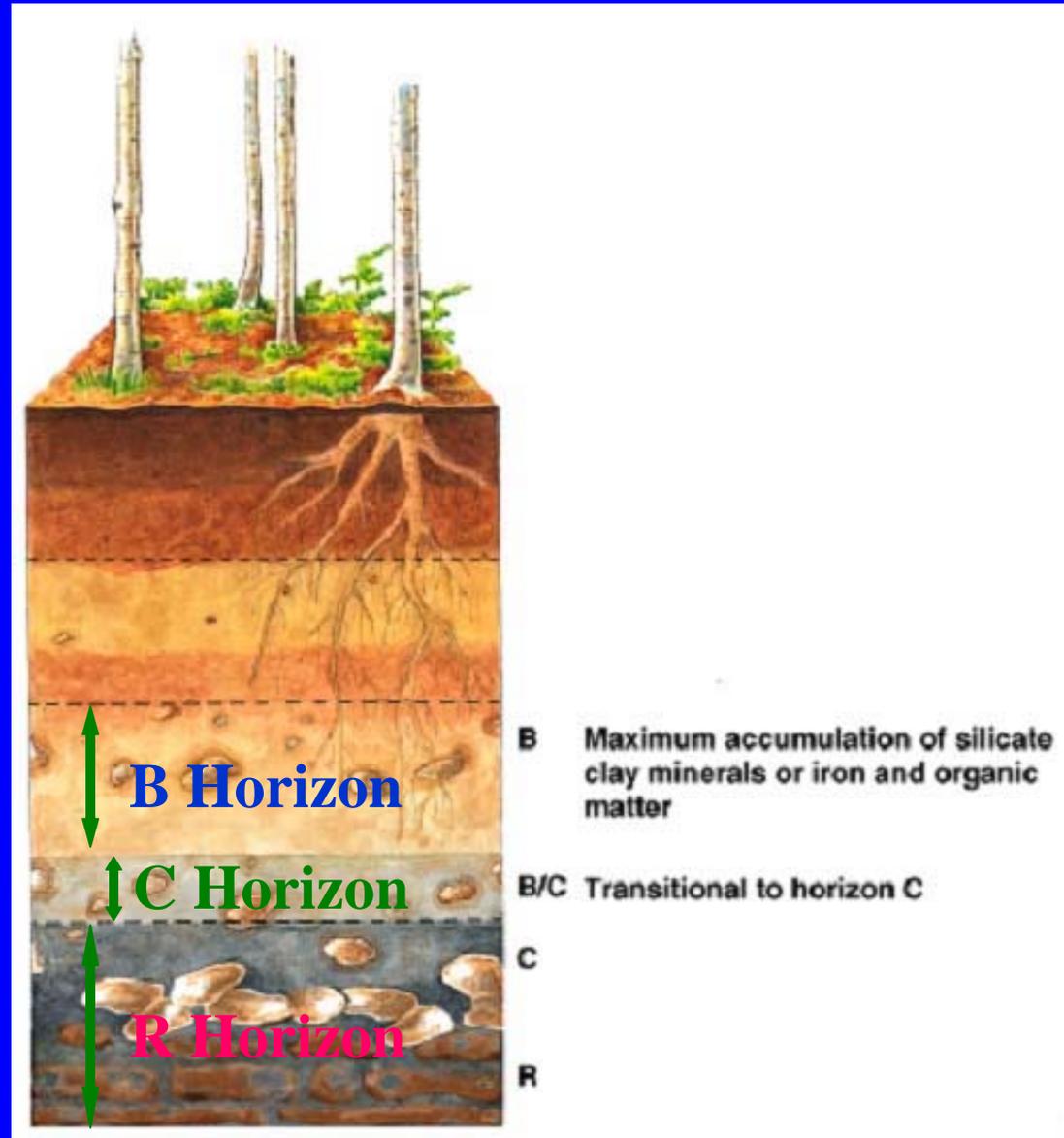
- **O Horizon** - Litter - Undecomposed or partially decomposed organic material ;(O_i+O_a).
- **A Horizon** - (Topsoil) Uppermost layer - contains most of the soil nutrients and organic matter (organic matter + mineral matter).
- **E Horizon** - Formed from leaching darker materials.
 - Not formed in all soils.
 - Usually very nutrient poor.

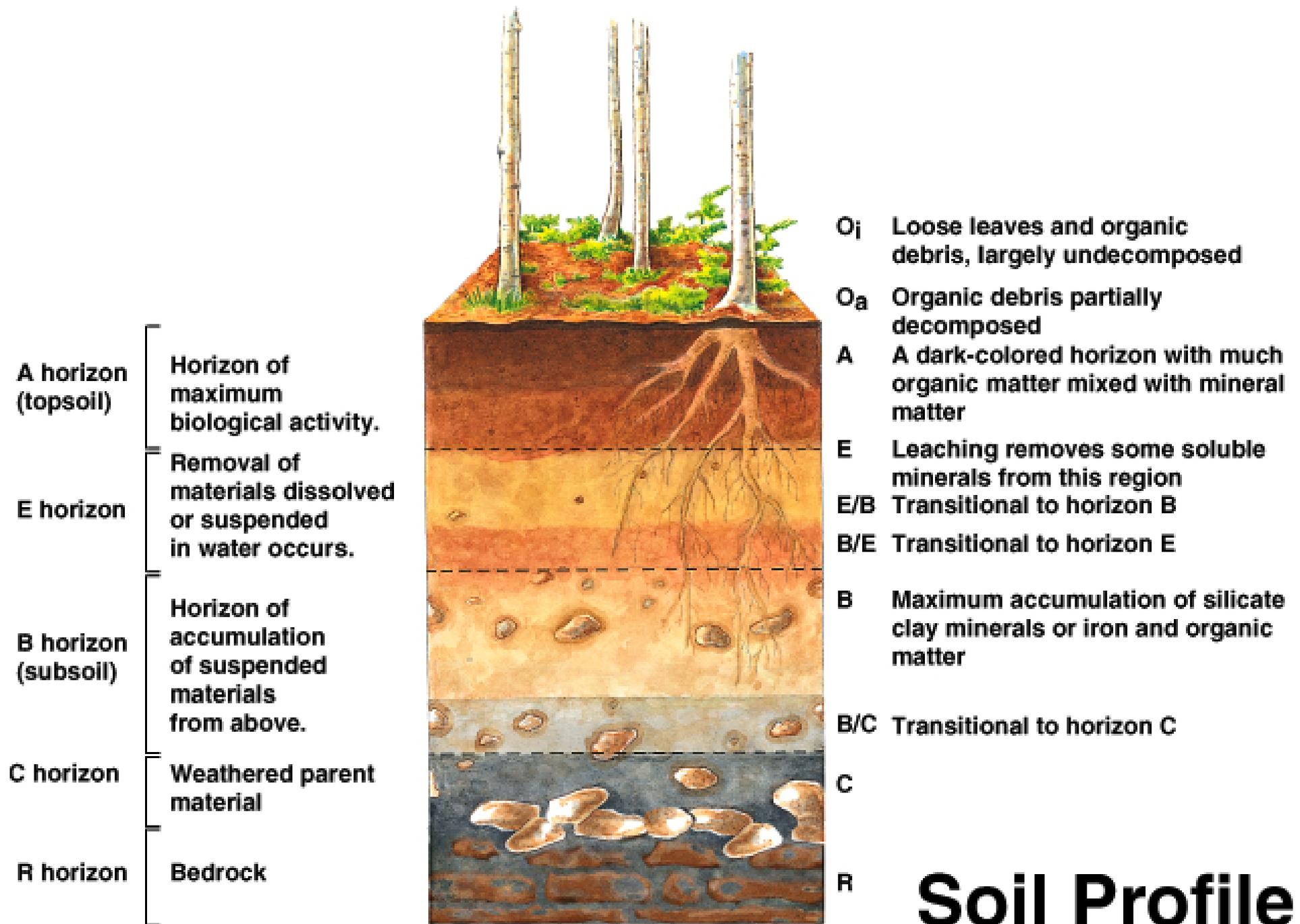


- O_i** Loose leaves and organic debris, largely undecomposed
- O_a** Organic debris partially decomposed
- A** A dark-colored horizon with much organic matter mixed with mineral matter
- E** Leaching removes some soluble minerals from this region
- E/B** Transitional to horizon B
- B/E** Transitional to horizon E

Soil Horizons

- **B Horizon** - (Subsoil)
Underneath topsoil. Contains less organic matter and fewer organisms, but accumulates nutrients leached from topsoil. - Poorly developed in dry areas.
- **C Horizon** -
Weathered parent material - very little organic material.
- **R Horizon** - Bedrock





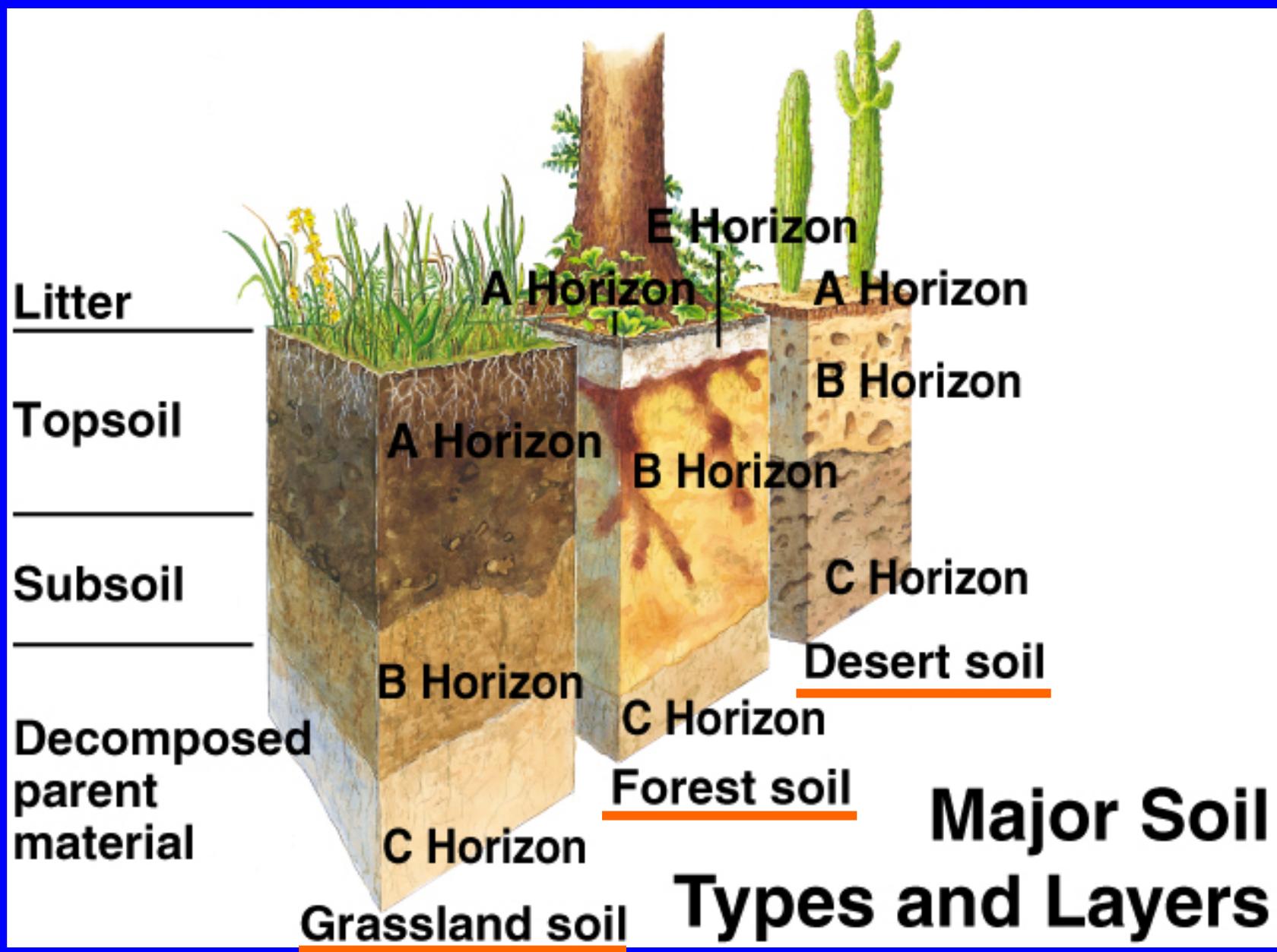
Soil Profile

Soil Profiles

- **Soil types**
 - Over 15,000 separate soil types have been classified in North America. However, most cultivated land can be classified as either grassland or forest soil.
- **Grassland Soils** - Usually have a deep A Horizon - low rainfall limits topsoil leaching. A Horizon supports most root growth.

Soil Profiles

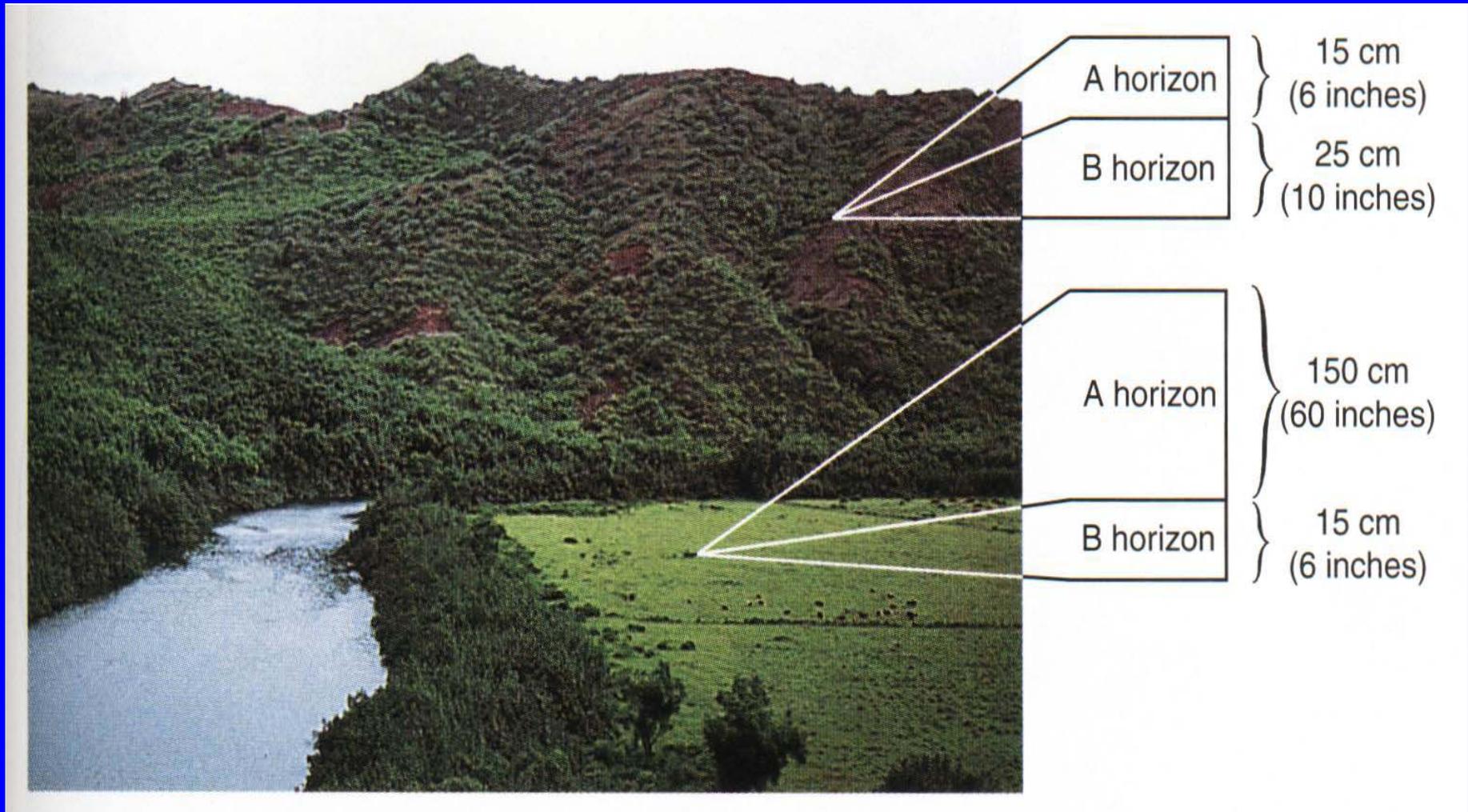
- **Forest Soils** - Topsoil layer is relatively thin, but topsoil leachate forms a subsoil that supports substantial root growth. (High rainfall areas)
 - **Tropical Rainforests**
 - ❖ Two features of great influence:
 - **High temperatures**
 - Rapid decomposition - little litter.
 - **High rainfall**
 - Excessive leaching of nutrients.
- **Therefore**, the soil profile is different with different type of soil.



Major Soil Types and Layers

Soil Profiles

- The effect of slope on a soil profiles.



Soil Erosion

- **Soil Erosion** (土壤侵蚀) – is the wearing away and transportation of soil by water, wind, or ice.
- Takes place everywhere in the world; worldwide removes 25.4 Billion tons/yr.
- Is a natural process; occurs wherever grass, bushes, and trees are disappears.
- Poor agricultural practices increase erosion.



Soil Erosion (土壤侵蚀)

- Wind erosion may not be as evident as water erosion, but is still common.
 - Most common in dry, treeless areas.



Soil Conservation Practices

- When topsoil is lost, fertility is reduced or destroyed, thus fertilizers must be used to restore fertility.
 - Raises food costs, and increases sediment loads in waterways.
 - Over 20% of US land is suitable for agriculture, but only 2% does not require some form of soil conservation practice.
- However, most current agricultural areas lose topsoil faster than it can be replenished (补充).

Soil Conservation Practices

- **Contour Farming** (仿地形耕种) - Tilling at right angles to the slope of the land. Each ridge acts as a small dam.



- (1) This allows more of the water to soak into the soil.
- (2) Reduces soil erosion by as much as 50 percent.
- (3) In drier regions, increases crops yields by conserving water.

Soil Conservation Practices

- When the slope is too steep or too long, contour farming along may not prevent soil erosion.
- **Strip Farming** - Alternating strips of closely sown crops (like hay, wheat, or their small grains) with strips of row crops (like corn, soybean, cotton, or sugar beets).

Soil Conservation Practices

- Strip Farming



The closely sown crops slow water flow, which reduces soil erosion and allows more water to be adsorbed in to the ground.



Soil Conservation Practices

- **Terracing** - Level areas constructed at right angles to the slope to retain water - good for very steep land.



Soil Conservation Practices

- **Waterways** - Depressions in sloping land where water collects and flows off the land.



If the waterway is maintained with a permanent sod covering, ...



speed of the water is reduced, the roots tend to hold the soil particles in place, and soil erosion is decreased.

Soil Conservation Practices

- **Windbreaks** - Planting of trees or other plants that protect bare soil from full force of the wind.



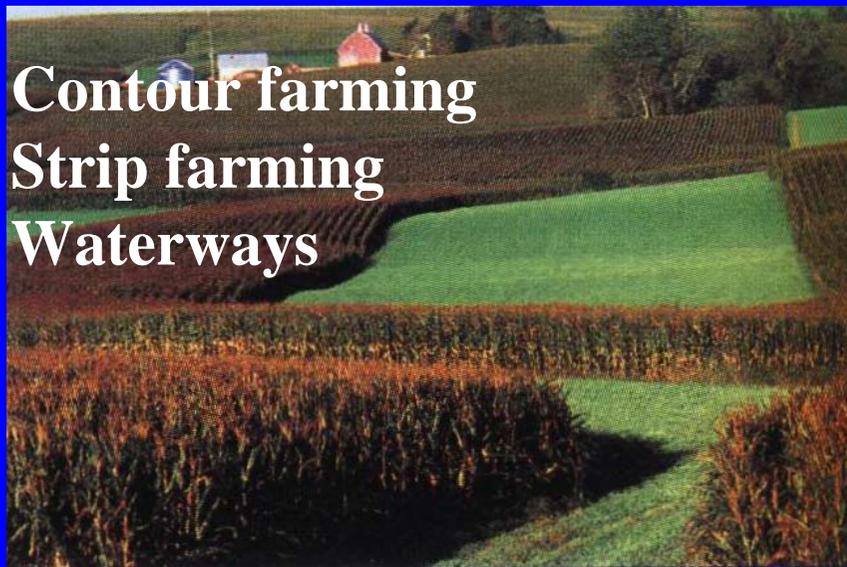
Windbreaks reduce the velocity of the wind, thereby decreasing the amount of soil that can be carry away. Therefore, the wind erosion can be reduced.

Soil Conservation Practices

- Poor and proper soil conservation practices



This land is no longer productive farmland due to erosion has removed the topsoil and its fertility is destroyed.



Contour farming
Strip farming
Waterways

This rolling farmland shows strip contour farming to eliminate soil erosion by running water. It should continue indefinitely to be productive farmland.

Conventional vs. Conservation Tillage

- **Conventional tillage:**
 - Require extensive use of farm machinery to prepare the soil for planting and to control weeds.
 - Typically, the field is plowed and then disked or harrowed one to three times before the crop is planted
- **Plowing (turns the soil over) has multiple desirable effects:**
 - Weeds and weed seeds are buried / destroyed.
 - Crop residue is turned under - decays faster and helps build soil structure.
 - Leached nutrients brought closer to surface.
 - Cooler, darker soil brought to top and warmed.

Conventional tillage

- Fields are plowed in the fall, after the crop has been harvested and the soil is left exposed all winter. This increases the amount of time the soil is open to erosion via wind or water.
- Each trip over the field is an added expense to the farmer.

Therefore, new systems of tillage have been developed:

- **Reduced Tillage** - Uses less cultivation to control weeds and prepare soil, but generally leaves 15-30% of soil surface covered with crop residue after planting.

控制田间杂草和备耕时尽可能采用较少的耕作行为，通常在耕种后保留15-30%的土壤面积覆盖有秸秆（crop residue）。

Conservation Tillage

- **Conservation Tillage** - Further reduce amount of disturbance and leaves 30% or more of soil surface covered with crop residue.
 - ❖ **Mulch Tillage** (覆被耕种)- Tilling entire surface just prior to planting.
 - ❖ **Strip Tillage** (间耕) - Tilling narrow strips that is to receive the seeds.
 - ❖ **Ridge Tillage** (垄耕) - Leave ridge and plant the crop on the ridge with residual left between the ridges.
 - ❖ **No Till farming** (点耕) - Place seeds in slits .

Conservation Tillage

- **Advantages:**

Reduce the amount of time and fuel needed by the farmer to produce the crop and, therefore represent an economic saving.

Reduce soil erosion.

- **Disadvantages:**

The crop residue: delay the warming of soil;

reduce the evaporation from soil;

reduce the upward movement of water;

reduce nutrients from deeper layer of soil;

The accumulation of plant residue can harbor plant pests and diseases

Conservation Tillage

- **Therefore,**

Conservation tillage is not the complete answers to soil erosion problems.

But may be useful in the well-drained soil.

It also requires the farmers pay close attention to the condition of the soil and pests to be dealt with.

Summary

- **Geologic Processes:**
 - The movement of the tectonic plates results in the formation of new land
 - Weathering
- **Soil Formation:** begins with the breakdown of the parent material. Many factors involved in the process of soil formation.
- **Soil Properties and soil profile:** topsoil contains a mixture of humus and inorganic matter, both of which supply soil nutrients.
- **Soil Erosion:** removal and transportation of soil by water, wind, or ice.
- **Soil Conservation:**
 - Tillage Practices

Concept map

Construct a map to show the relationships among the following concepts:

- 土壤 (soil)
- 原生材料 (parent material)
- 土壤剖面 (soil profile)
- 水土保持 (soil conservation practices)
- 土壤侵蚀 (soil erosion)
- 仿地形耕种 (contour farming)
- 间耕耕种 (strip farming)
- 防风隔断 (windbreaks)

Review Questions

- How are soil and land different?
- Name the five major components of soil.
- Describe the process of soil formation.
- Describe a soil profile.
- Define erosion.
- Describe three soil conservation practices that help to reduce soil erosion.

