Course Book of
Principles of Soil Science

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- **Academic Year: 2022 - 2023**

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- **1-** Introductory of **soil science**, soil definition, soil science classifications, Pedology and
- Pedology sciences , Edaphology and Edaphology sciences,
- **2- Traditional and modern classification of soil science**, soil science relations with other
- sciences, soil and ecosystem.
- **3-** Soil components, soil profile, horizons, soil formations and processes of **soil formation**,
- weathering produced soil
- **4- Soil physics**, soil characterization, soil texture, soil texture classification, systems, triangle,
- Canadian soil classification.
- **5-** Water molecules with clay surface. **Soil water**, soil water composition, soil water classification, soil type and moisture, soil moisture calculation.
- **6- Structure,** classification, factors affects on structure, soil density, soil bulk density, bulk
- density and compactions, bulk density and particle density.

7- Porosity, soil component, pore spaces, porosity calculating, soil **color**.

- **8- Soil chemistry,** soil reactions, pH ranges, water molecules, pH importance, soil buffer
- capacity, Buffer mechanism, base saturation. Acidity, soil structure and pH.
- **9-** Cation Exchange Capacity **(CEC)** ,CEC importance, CEC and plant growth, colloids, CEC
- illustrated, CEC process, comparison between high and low CEC.

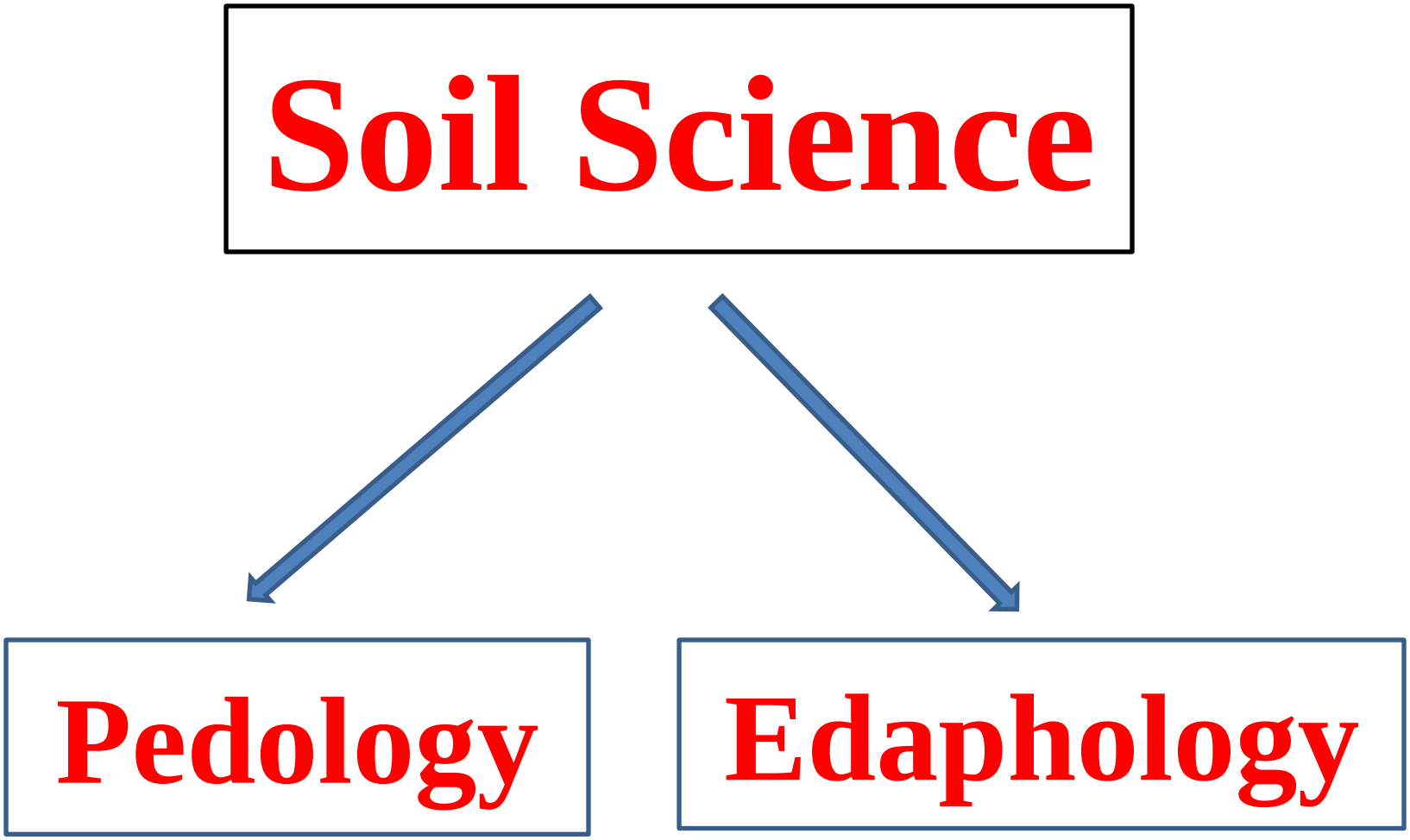
10- Soil organic matter, fertilizers, global fertilizer usage, inorganic fertilizers,

- **11**- Land degradation and **soil conservation**, erosion, eroded methods , prevent erosion,
- desertification, productivity and costs,
- **12-** The crop rotation, soil terracing and planting, **plant cover** and erosion,

13- Soil microbiology, abundance of soil organisms, Bacteria, some important bacteria, earth worm, actinomysets, important products, Fungi.

Soil Definitions

- An **agricultural** definition of soil is : a dynamic natural body on the surface of the earth in which plants grow, composed of mineral, organic materials and living organisms form.
- An **engineering** definition of soil is : all the fragmented mineral material at or near the surface of the earth, the moon, or other planetary body, plus the air, water, organic matter, and other substances which may be included therein.
- **Geological** definitions of soil depend on the interest of the geologist. "Hard rock" geologists tend to view soil as regolith, employing the engineering definition. Geomorphologists, however, are interested in soil forming processes and adopt definitions and classification systems developed primarily for agriculturists


Soil Science
Pedology
Edaphology

Pedology

- Pedology is a Greek word and it is a branch of soil science which is dealing with the laws of **origin formation** and **geographic distribution** of the soil as a body , it has three dimensions (length, width , and depth) in the nature
- **Pedology** comprises soil sciences below:

1. **Soil Genesis**
2. **Soil Morphology**
3. **Soil Survey and Classification**
4. **Soil Mineralogy**

Edaphology

Edaphology is a Greek word and it is an other branch of soil science which is dealing with the influence of soils on living things, particularly -chiefly- plant, including human use of land for plant growth or deals with the study of soil in relations to growth of plants, nutrition &yield of crops. Edaphology comprises soil sciences below:

1. **Soil Chemistry.**
2. **Soil Physics .**
3. **Soil Fertility & Plant nutrition.**
4. **Soil Microbiology.**
5. **Soil Conservation.**

Traditional Division of Soil Science

SOIL SCIENCE	**PEDOLOGY**	**Soil Genesis**
		Soil Morphology
		Soil Survey & Classification
		Soil Mineralogy
	EDAPHOLOGY	Soil Chemistry
		Soil Physics
		Soil Microbiology
		Soil Fertility and Plant Nutrition
		Soil Conservation

Modern Division of Soil Science

D1. **1. Soil In Space and Time**	**C1. 1. Soil Morphology**
	C1. 2. Soil Geography
	C1. 3. Soil Genesis
	C1. 4. Soil Classification
D2. **2. Soil Properties and Process**	C2.1. Soil Physics
	C2.2. Soil Chemistry
	C2.3. Soil Biology
	C2.4. Soil Mineralogy

Continued

D3. **3. Soil Use and Management**	**C3.1. Soil Evaluation and Land use**
	C3.2. Soil and Water Conservation
	C3.3. Soil Fertility and Plant nutrition
	C3.4. Soil Engineering and Technology
	C3.5. Soil Degradation Control, Remediation and Reclamation
D4. **4. The Role of Soils in Sustaining Society and the Environment**	C4.1. Soils and the Environment
	C4.2. Soils, Food Security, and Human Health
	C4.3. Soils and Land Use Change
	C4.4. Soils Education and Public Awareness
	C4.5. History, Philosophy, and Sociology of Soil Science

Related Disciplines of Soil Science

Soil science is very much related to some basic sciences and applied science courses like:-

Basic sciences such as: Physics, Chemistry, Mathematics, Biology, Statistics, Computer Science, Geology, Geography, Soil Mechanics, Geophysics, Watershed Planning and Management.

Applied sciences such as:

Land use Planning, Environmental Science, GIS and Remote Sensing, Hydrology, Agronomy, Plant Physiology, and Microclimatology.

* ***Postgraduate students in soil science should be exposed to fundamentals of the above related basic science and applied science courses.***

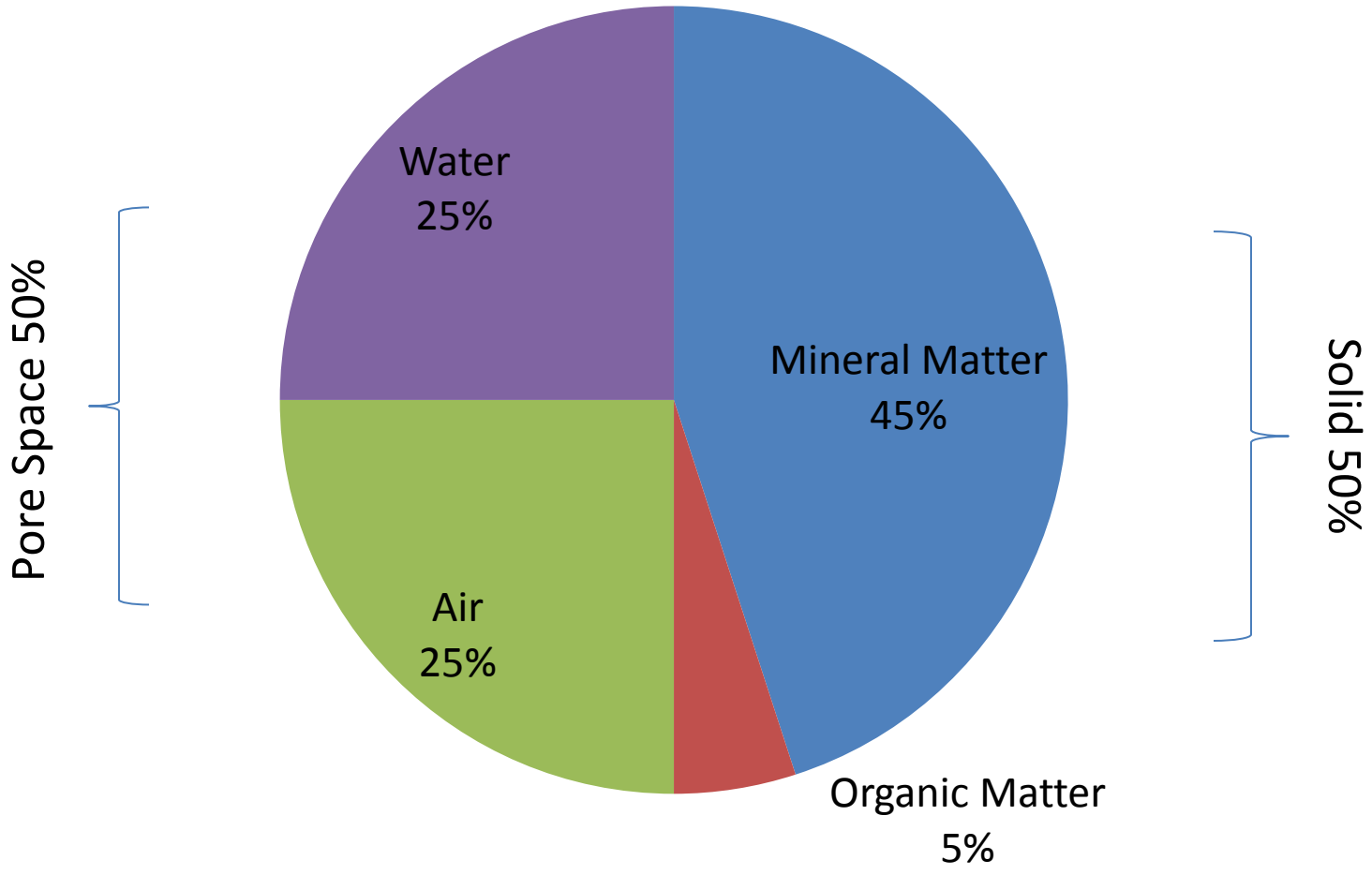
Functions of Soil in the Global Ecosystem

Soils perform five key function in the global ecosystem:

1) Medium for plant growth.
2) Regulator of water supplies.
3) Recycler of raw materials.
4) Habitat for soil organisms
5) Landscaping and engineering mediums.

Components of Soil

Soil consists of a solid phase (minerals and organic matter) as well as a porous phase that holds gases and water. Accordingly, soils are often treated as a three-state system.



Soil profile

Soil profile : Is a suction of soil from soil surface to bed rock. Consists of layers called **horizons**.

or a vertical exposure of a soil consisting o the horizons is a soil profile

Soil horizon: Is a layer of soil parallel

to soil surface.

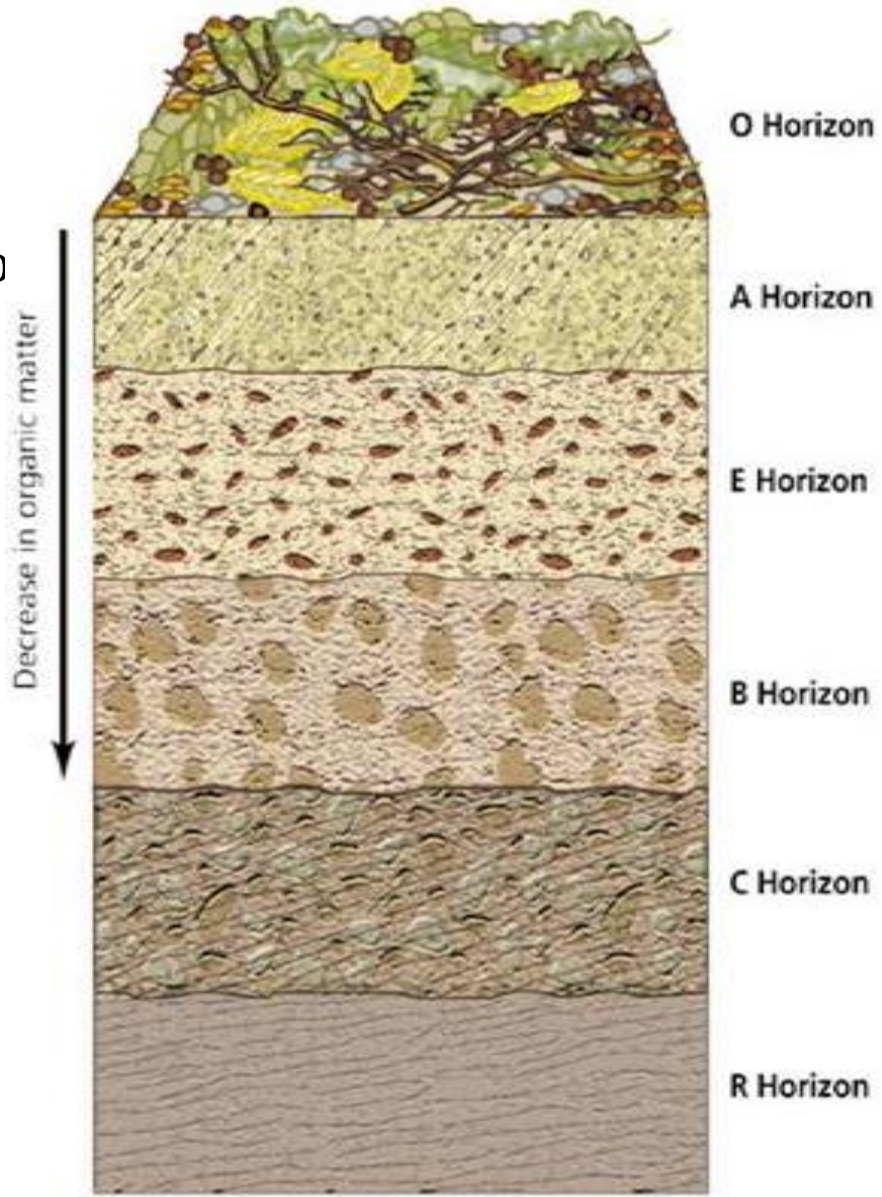
Simplest:

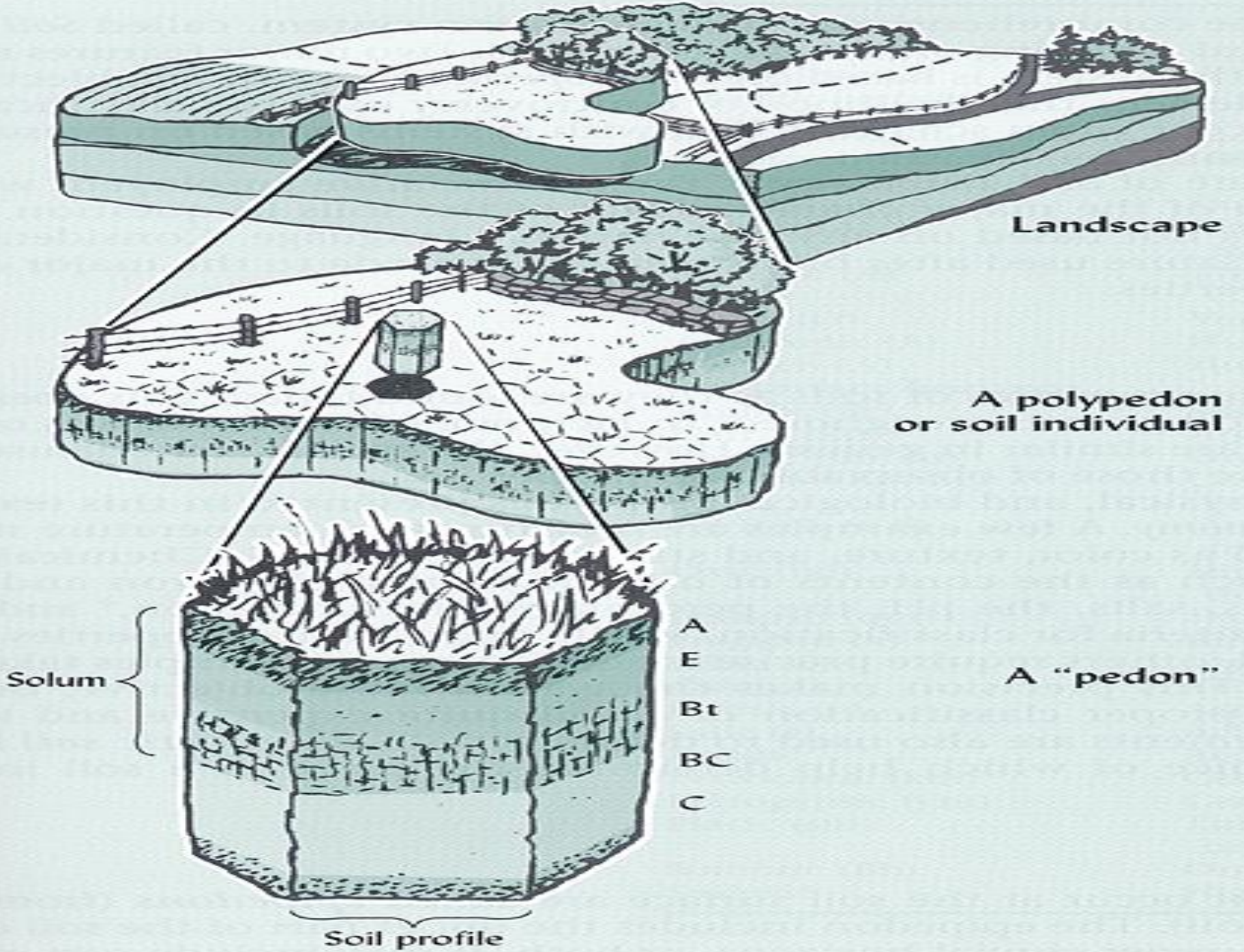
A *= topsoil*

B *= subsoil*

C *= parent material*

But most have **O, A, E, B, C**, and **R**




Landscape
A polypedon
or soil individual
A "pedon"
Solum
A
E
Bt
BC
C
Soil profile

Soil Profile

O Horizon: Organic or litter layer.

A Horizon: Topsoil. Mostly inorganic minerals with some organic material and humus mixed in, Crucial (vital) for plant growth

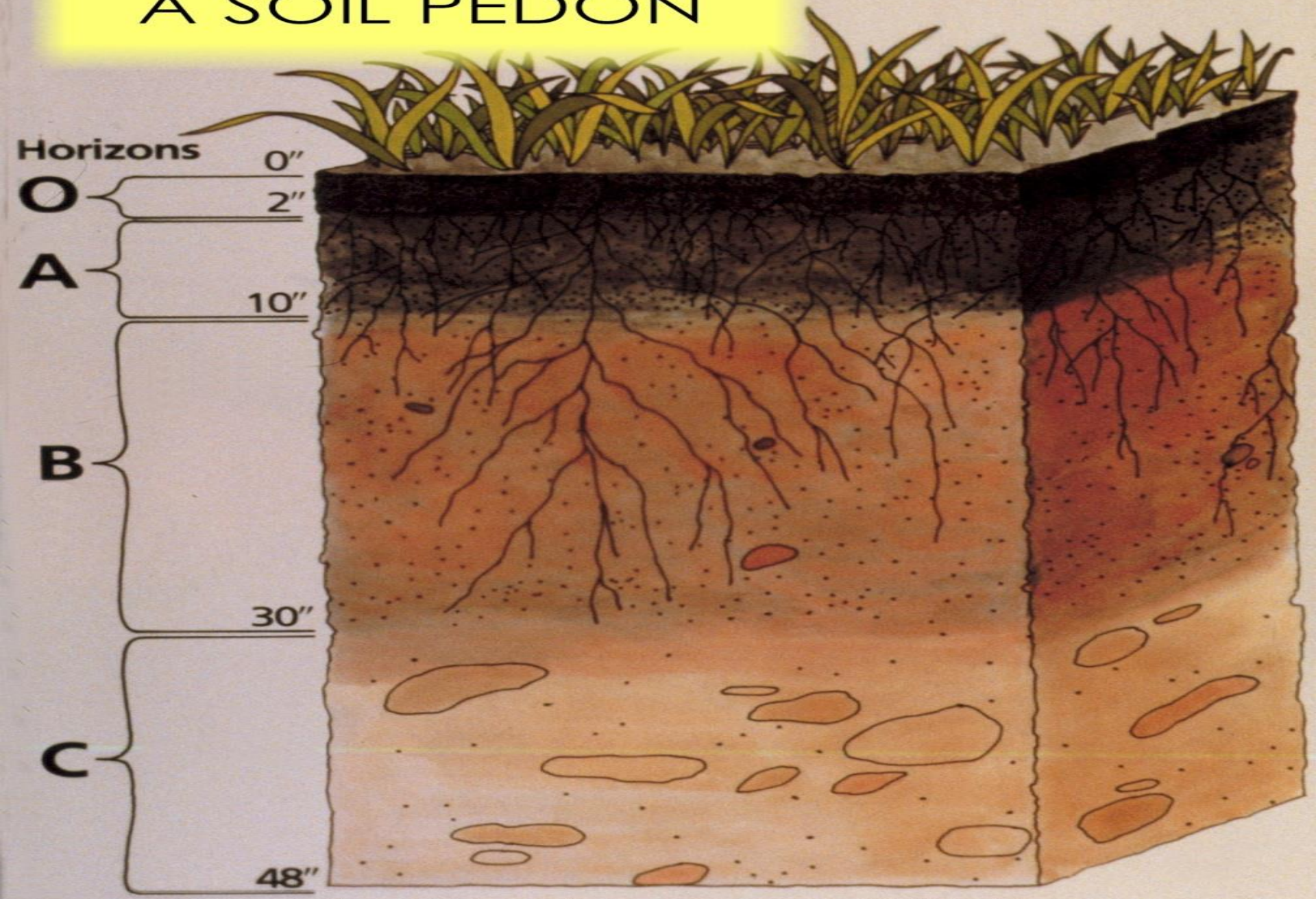
Eluvial horizon -Eluviations horizon-loss of minerals by **leaching**, a process whereby solid materials are dissolved and transported away.

B Horizon: Subsoil. Zone of accumulation or deposition of leached minerals – Illuviation horizon- and organic acids from above.

C Horizon: Slightly altered parent material

R Horizon: Bedrock.

A SOIL PEDON



SOIL FORMATION

Soil layers are approximately parallel to the land surface and several layers may evolve simultaneously في الوقت نفسه over a period of time.

The layers in a soil are genetically related; however, the layers differ from each other in their physical, chemical, and biological properties.

In soil terminology, the layers are called horizons. Because soils as natural bodies are characterized by genetically developed horizons, soil formation consists of the evolution of soil horizons.

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Soil formation is a slow and complex process

Parent material = The base geologic material of soil , Lava, volcanic ash, rock, dunes

Bedrock = Solid rock comprising the Earth's crust

Weathering = Processes that form soil

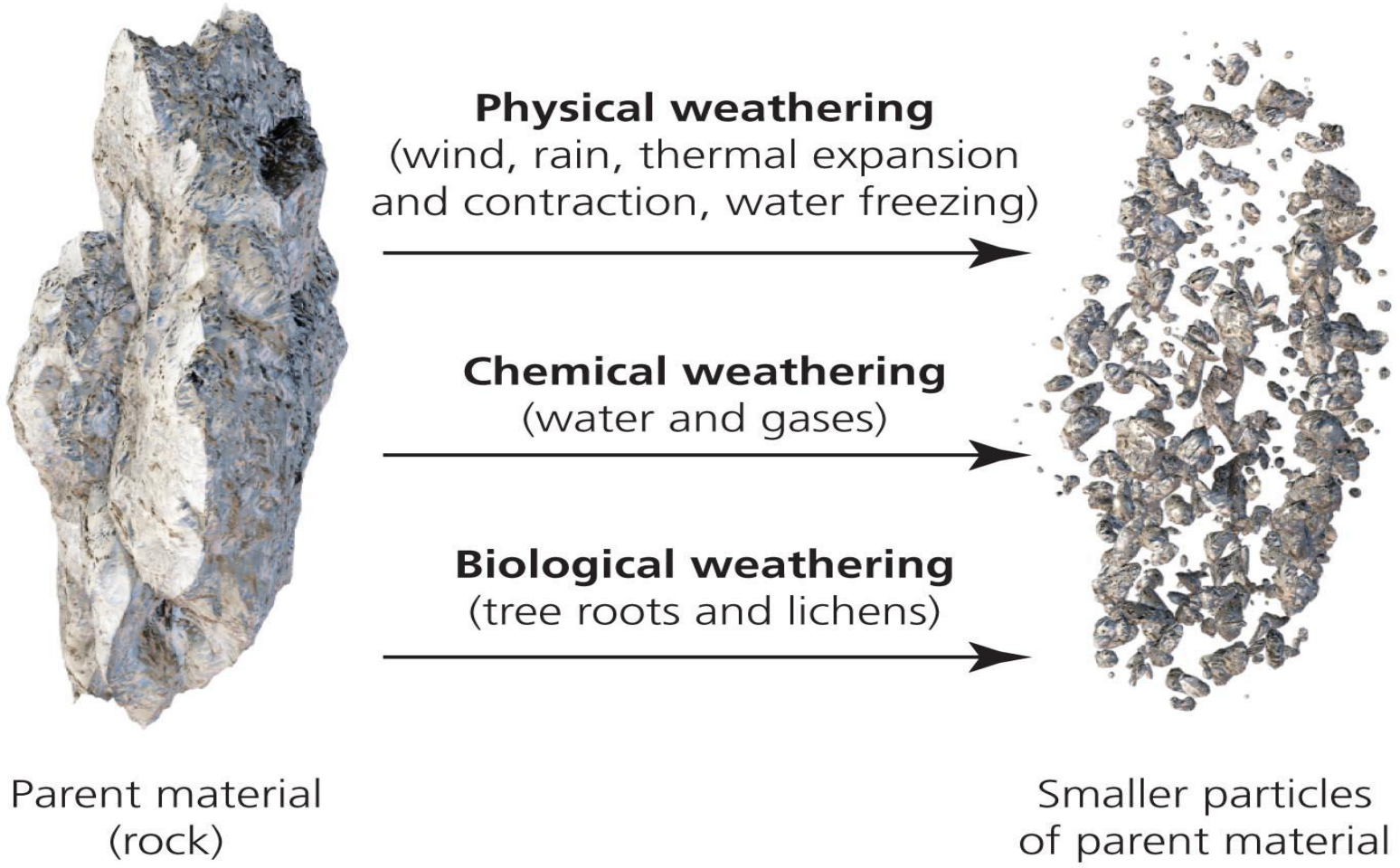
Physical (mechanical) = Wind and rain; no chemical changes in the parent material

Chemical = Substances chemically interact with (PM) (chemically changed)

Biological = Organisms break down (PM) and produce soil through physical or chemical means

Humus = Spongy, fertile material formed by partial decomposition of organic matter

Weathering produces soil



Key processes in soil formation

Key processes in forming soil: weathering and the accumulation of parent materials and transformation of organic matter.

They are influenced by the following factors:

Climate (Cl) : soils form faster in warm, wet climates

Organisms (O) : plants and decomposers add organic matter

Topography(R): hills and valleys affect exposure to sun, wind, and water.

Parent material (P): influences properties of resulting soil

Time (T): soil can take decades to millennia to form.

$$S = F\ (Cl, O, R, P, T..)$$

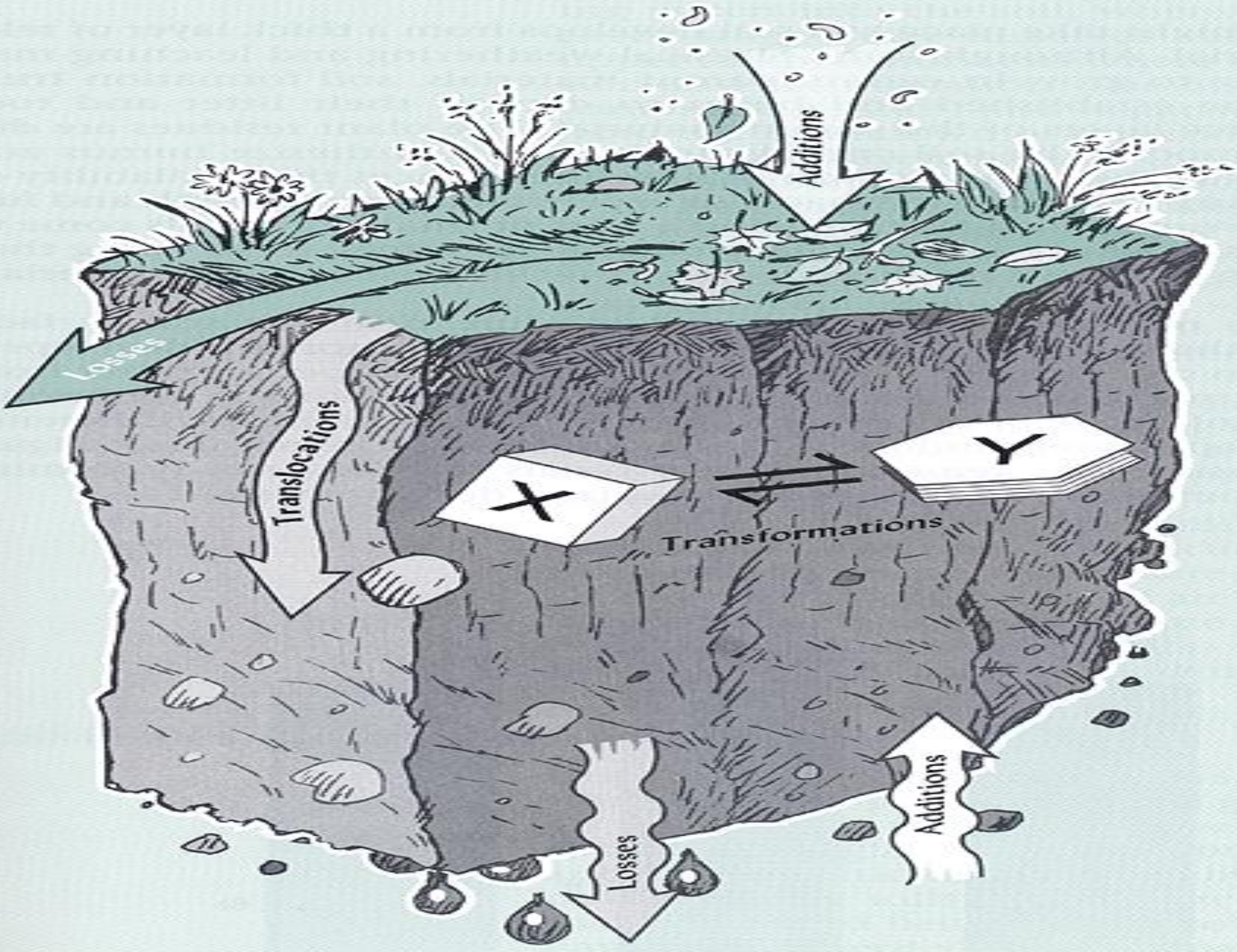
Soil forming processes

1- Addition.

2- Losses.

3- Transformation.

4- Translocation.


Additions
Losses
Translocations
X
Y
Transformations
Losses
Additions

Orders of Soil Taxonomy

1- Alfisols high base saturation – areas with low rain fall, but wetter than deserts.

2- Andisols volcanic ash affected

3-Aridosols deserts

4- Entisols "young" soils (floodplain ,mountains , desert, etc.)

5- Geisols permafrost – affected soils

6- Histosols Organic soils ,common in wet and cold areas (marshes ,muskeg, etc.)

7-Inceptisols Fairly "young" soils – soil development more advanced than Entisols

8-Molisols thick ,dark surface - humid and sub-humid grasslands(corn belt)

9- Oxisols very low fertility ,very "old" soils -humid tropics

10-Spodosols humid temperature woodlands, acidic

11-Ultisols low base saturation – humid warm – temperature, sub- tropics and tropics low fertility , acidic.

12-Vertisols

Soil physics

- Soil physics is a branch of soil science which deals with the mechanical behavior (i.e. physical properties) of soils as well as mechanical processes that take place in and through the soil.
- One of the fundamental subject of soil science is soil physics which deals with the study of mechanics, heat ,optics as they related to soil.
- Soil physics is a branch of soil science dealing with the state and movement of matter and transformation of energy in the soil.

Soils are characterized in many ways

- Soils are classified by Color, Texture, Structure, and pH
- Soil color = indicates its composition and fertility
  - Black or dark brown = rich in organic matter
  - Pale gray or white = indicates leaching
- Soil texture = determined by the size of particles from smallest to largest: **clay**, **silt**, **sand**
  - **Loam** = soil with an even mixture of the three affects how easily air and water travel through the soil
  - Influences how easy soil is to cultivate

Soil characterization

Soil can be characterized by color and several other traits اثر ، ميزة

1- Texture (percentage of sand, silt, and clay).

2- Structure .

. 3- Porosity

4- Cation exchange capacity .

5- pH.

6- Parent Material.

. 7- Infiltration rate

. 8- Nutrient concentrations

Soil Texture

- Soil texture is the relative proportions of the various soil separates namely sand, silt, and clay in a given soil. Natural soils are the mixture of soil separates of infinite combinations.
- Therefore, it is necessary to have some limits of variations among the soil separates to group them into textural classes upon significant differences in physical properties of each textural class.
- So the proportion of each size group in a given soil can not be altered easily. That is why soil texture is considered as a basic property of a soil.

Soil texture classification

Silty soils

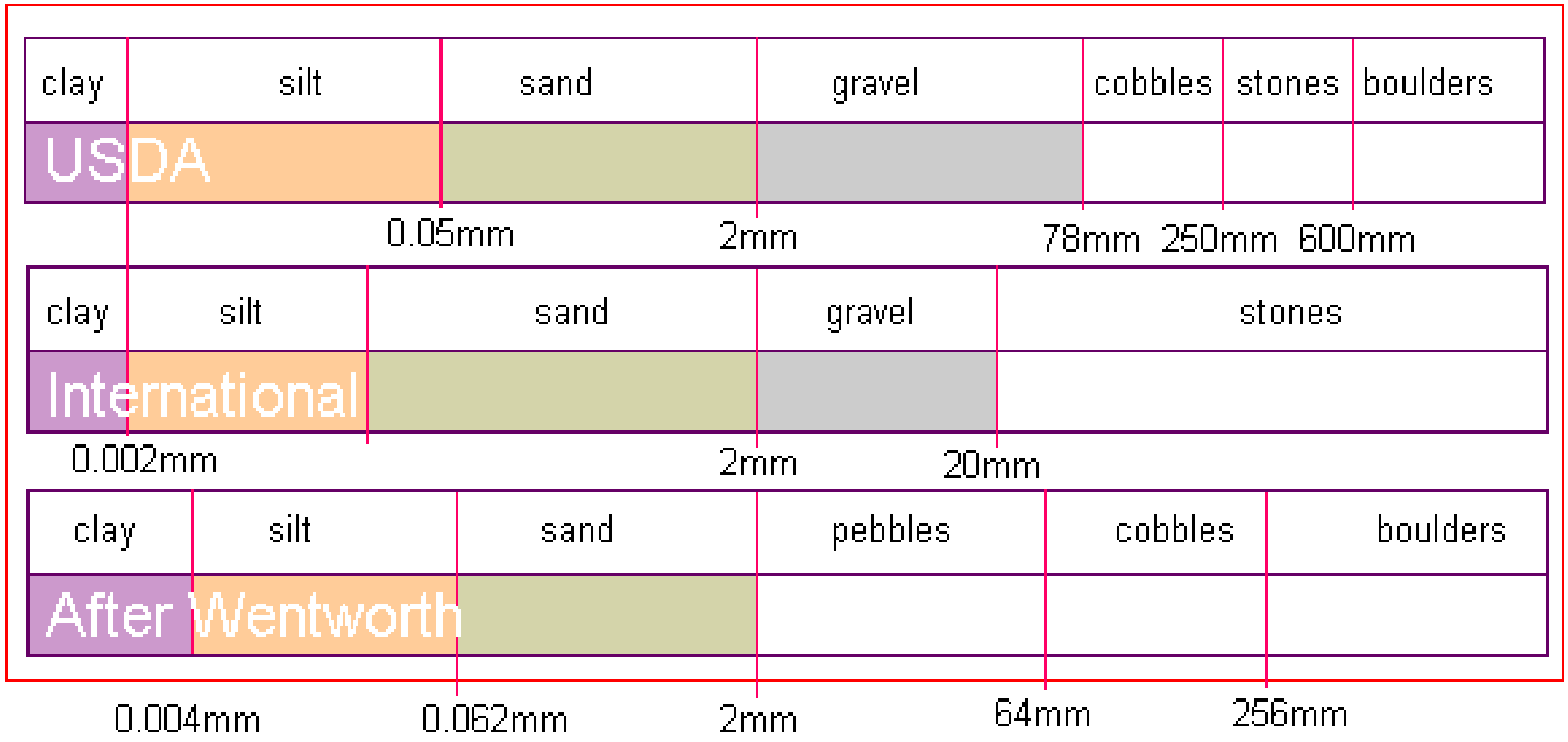
with

medium-size pores,

or loamy soils with mixtures of pore sizes,

are

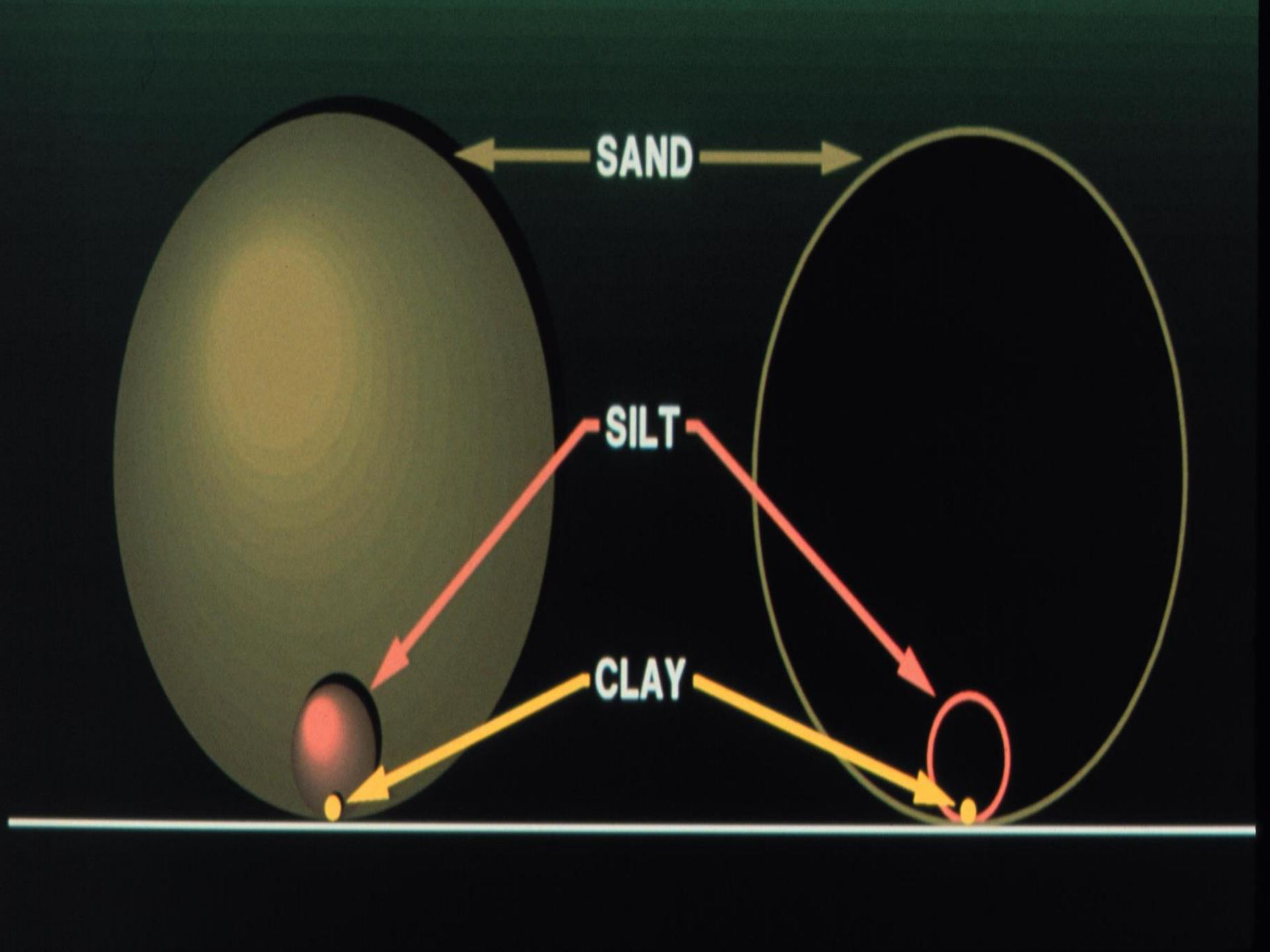
best for plant growth and agriculture.



Some commonly used soil particle size classification systems.

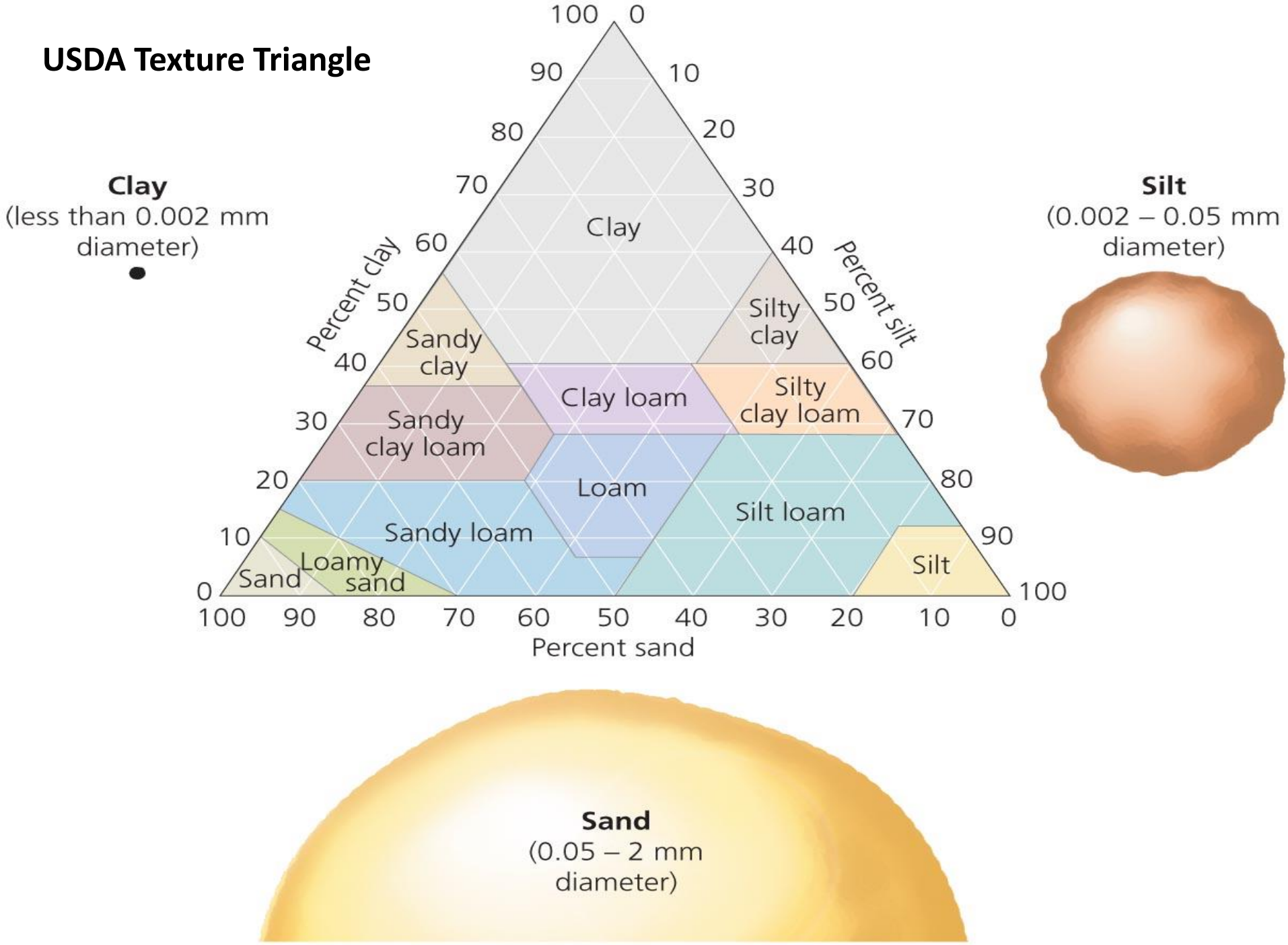
USDA: United States Department of Agriculture.

ISSS: International Society of Soil Science


SAND
SILT
CLAY

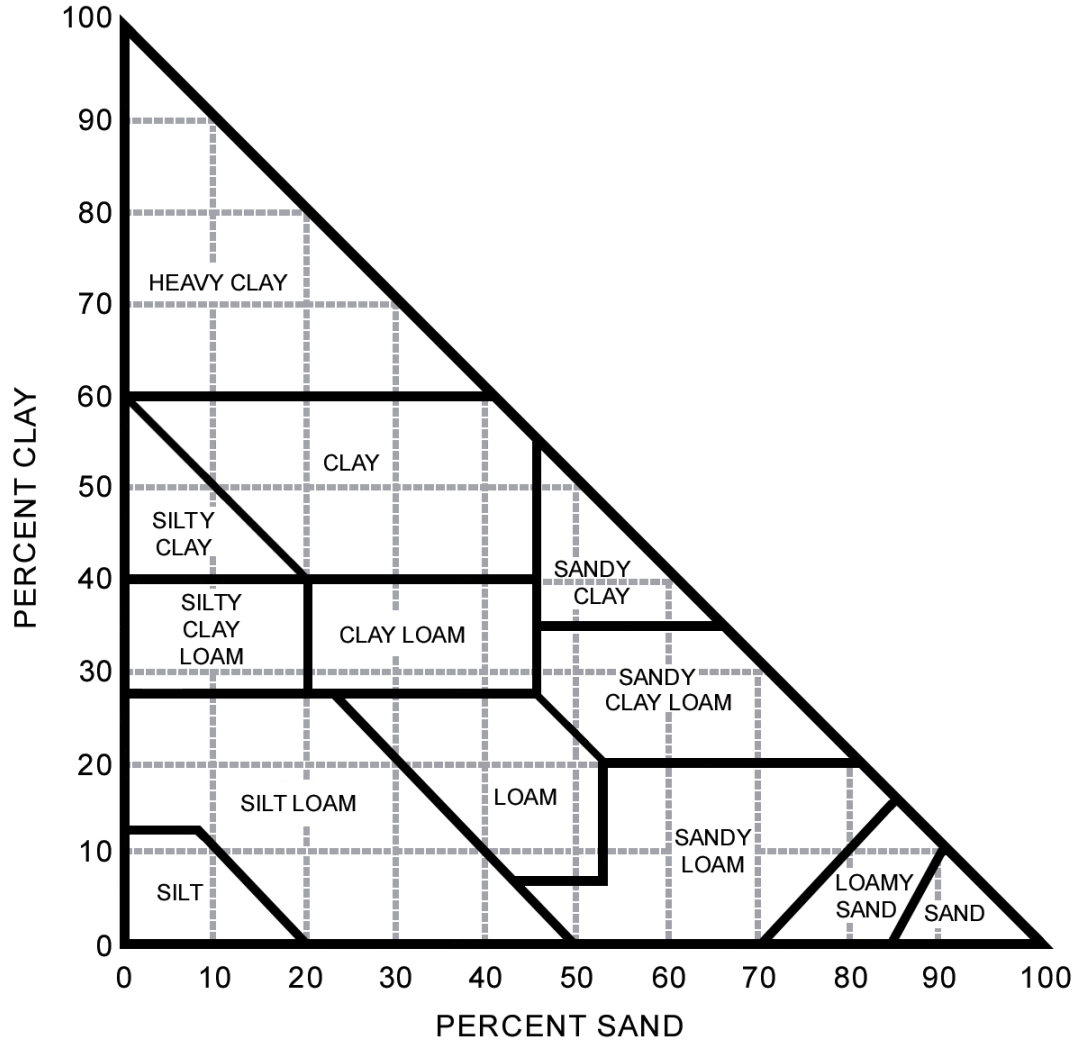
USDA Texture Triangle

Clay
(less than 0.002 mm diameter)



Silt
(0.002 – 0.05 mm diameter)

Sand
(0.05 – 2 mm diameter)



Soil textural classes in the Canadian System of Soil Classification

Soil Water

- Water affects soil formation, structure, stability and erosion but is of primary concern with respect to plant growth. Water is essential to plants for four reasons:

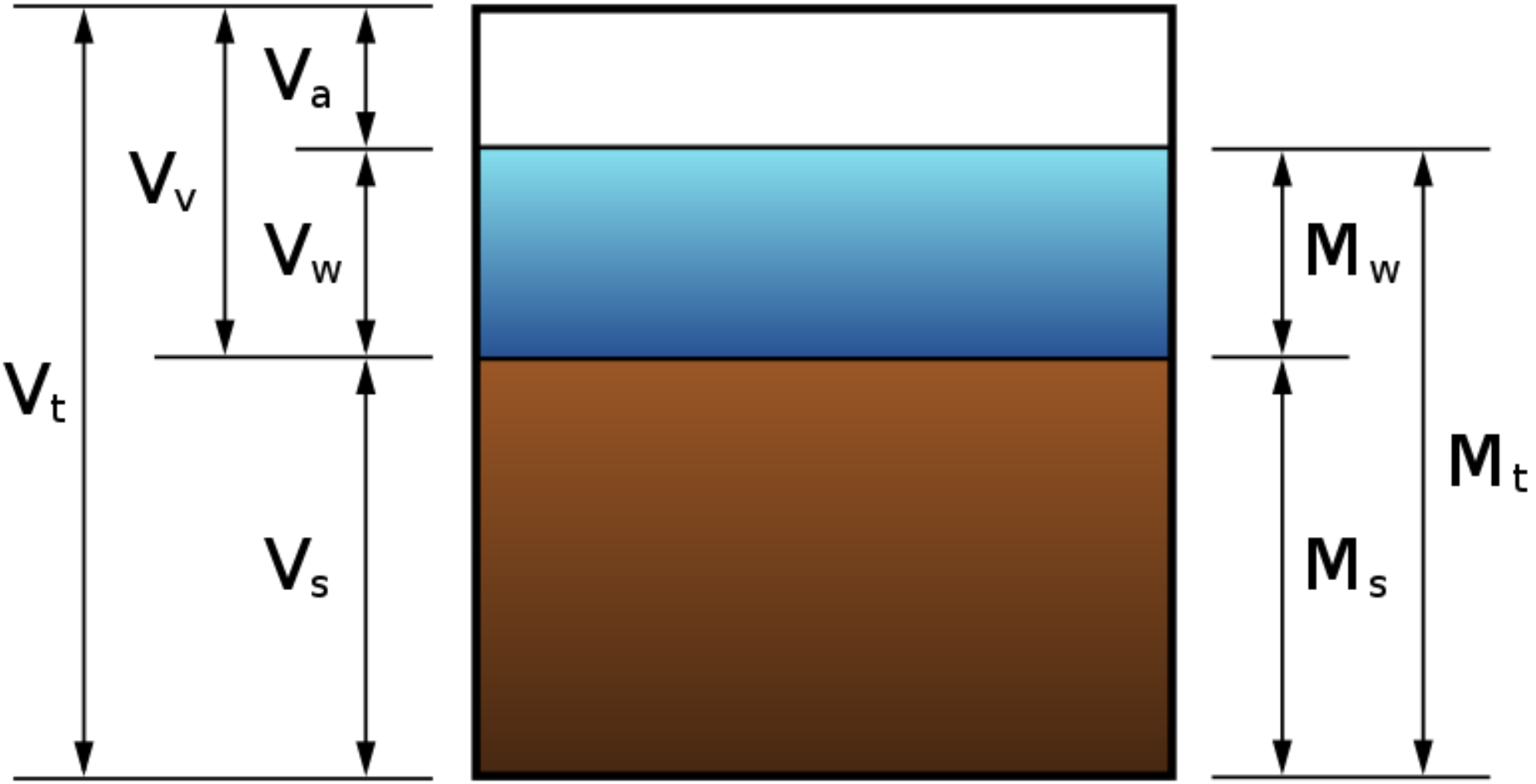
1- It constitutes 80%-95% of the plant's protoplasm.

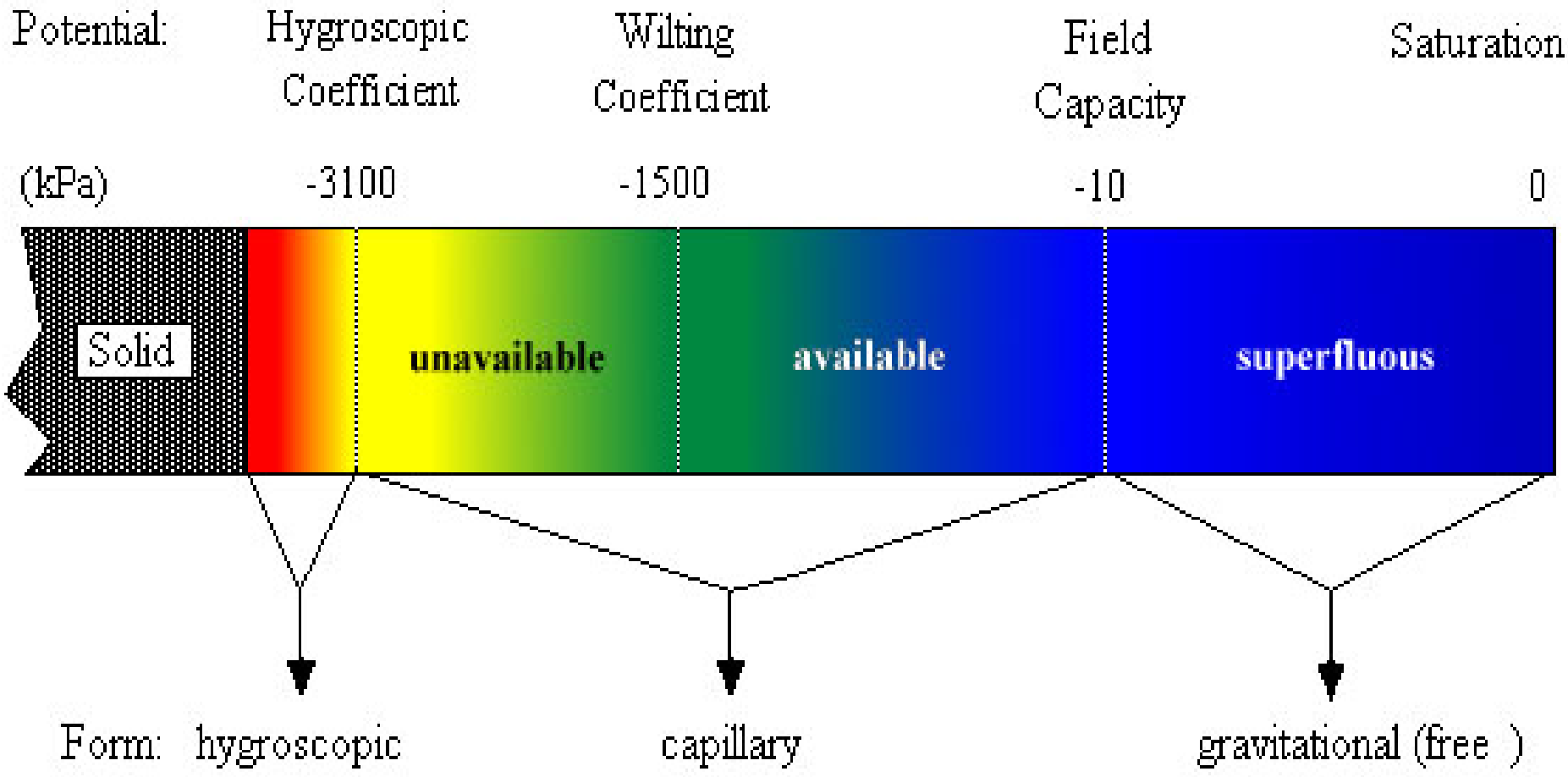
2- It is essential for photosynthesis.

3- It is the solvent in which nutrients are carried to, into and throughout the plant.

4- It provides the turgidity by which the plant keeps itself in proper position

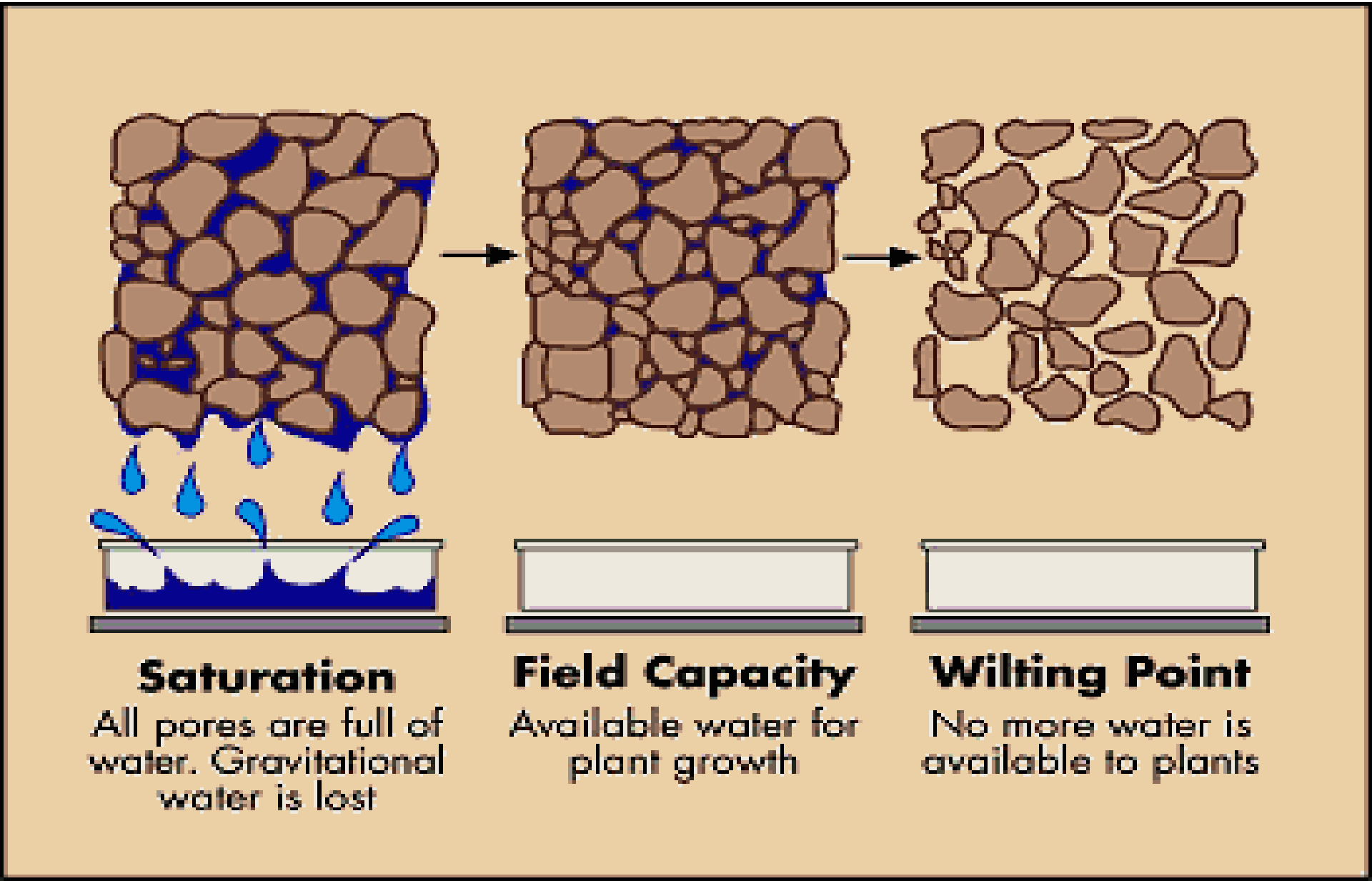
- Soil composition by phase: s-soil (dry), v-void (pores filled with water or air), w-water, a-air. V is volume, M is mass

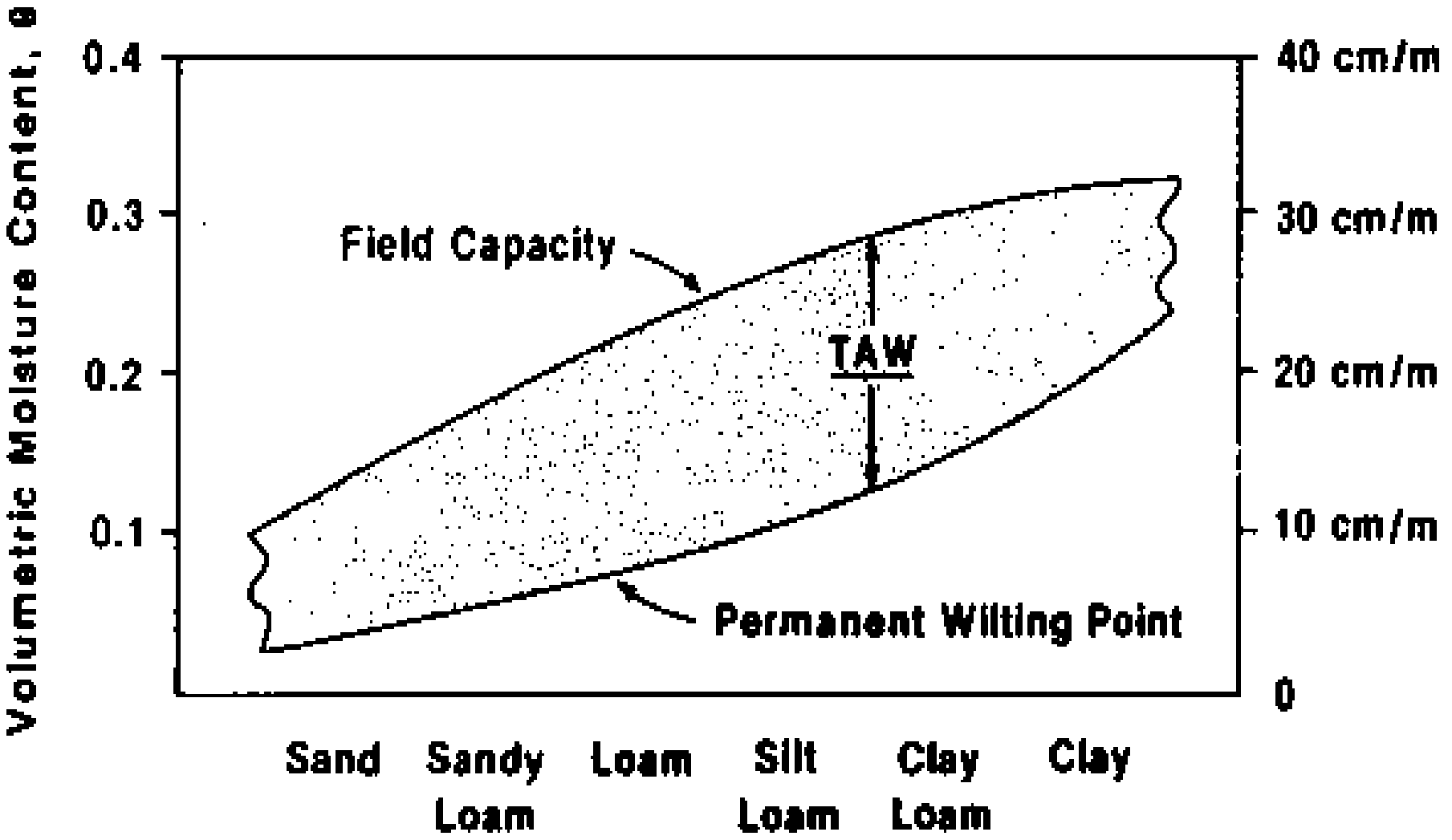




Classification of soil water (after Heaney, Crown and Palylyk, 1995).

Classification of soil water





Relationships between soil types and total available soil moisture holding capacity, field capacity and wilting point

Calculating Soil Moisture

1- Gravimetric

- The mass of water in a given mass of soil (kg of water per kg of soil).

- Pw = Percent water by weight or
- Pw = wt. water ÷ wt. O.D. soil
- Weight of water = (Wet Soil) - (O.D.Soil)

$$Pw = \frac{(\text{Mass of wet soil} - \text{Mass of oven dry soil})}{\text{Mass of oven dry soil}} \times 100$$

2-Volumetric

The volume of water in a given volume of soil (m^3 of water per m^3 of soil).

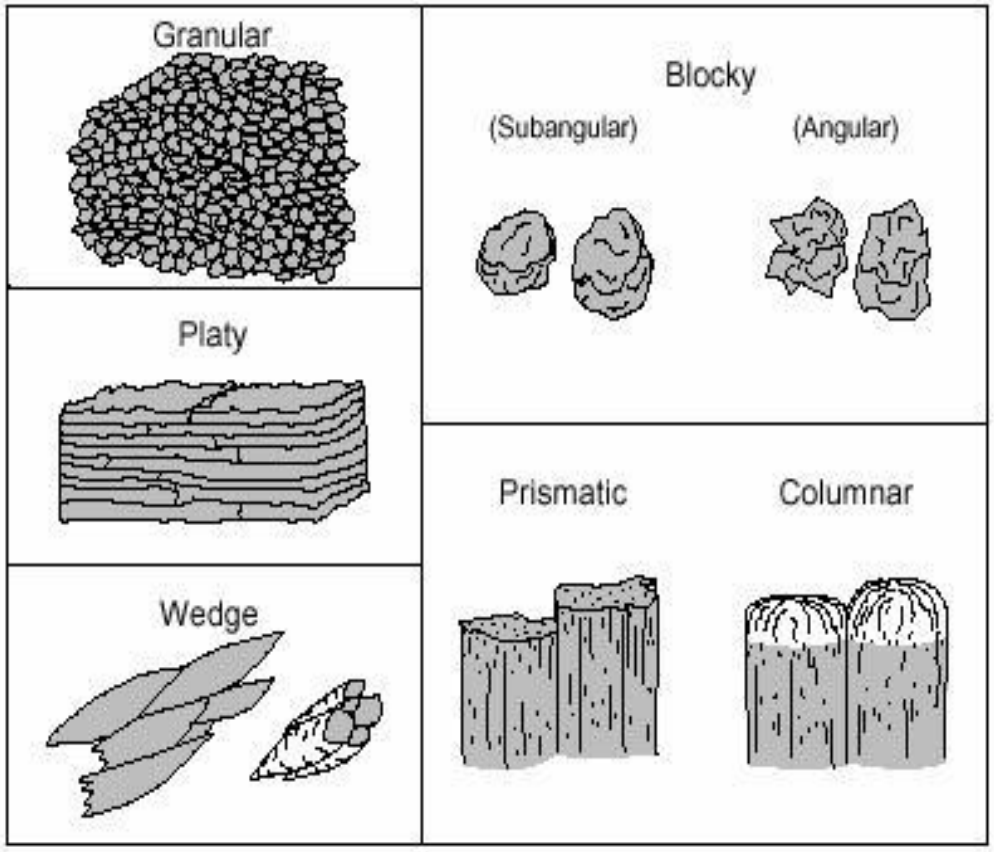
$$Pv = \frac{\text{(Volume of Water in } cm^3\text{)}}{\text{(Volume of soil in } cm^3\text{)}} \times 100$$

Pv = Percent volumetric

$Pv = P_w \times$ bulk density

Structure

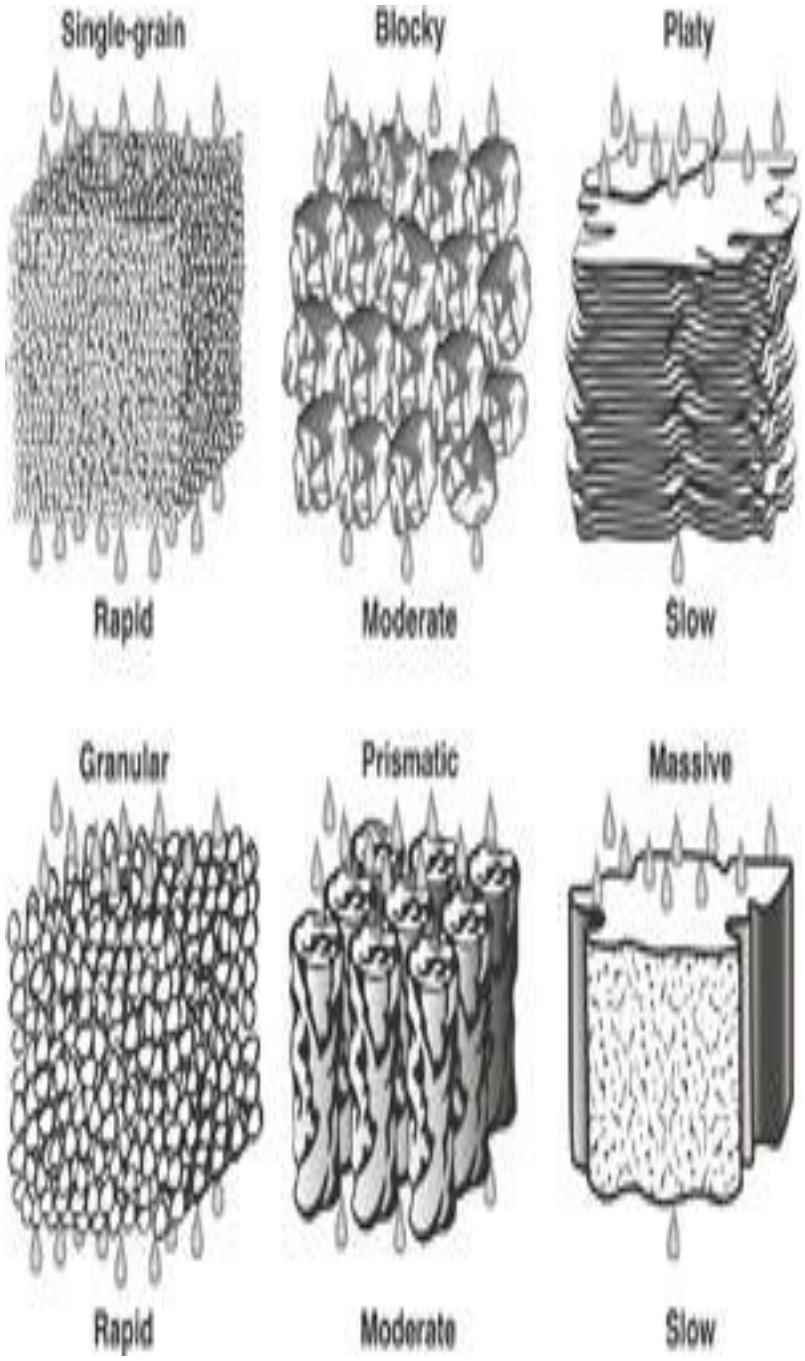
The clumping of the soil textural components of sand, silt and clay forms **aggregates** and the further association of those aggregates into larger units forms soil structures called **peds.**



Examples of Soil Structure

There are eight structural types commonly recognized in soil profiles:

1- Granular,
2- Single grain,
3- Blocky,
4-Prismatic,
5- Columnar,
6- Platy,
7- Wedge, and
8-Massive.



Structure

Affects permeability by influencing the path by which water can flow through the soil.

The type of structure determines the number of interconnected يربط شيئاً بآخر macro pores, which readily permit downward movement of water.

Aspects of Soil Structure

- The arrangement into aggregates of desirable shape and size
- The stability of the aggregate
- The configuration of the pores

Factors that affect…

Aggregate Stability

- Amount of clay
- Chemical elements
- Organic matter
- Biological activity

Soil Structure

- Organic matter
- Soil organisms
- Tillage
- **Freezing** and **thawing** أذاب
- Water movement

Important Note

- **All of these have a loosening effect on the soil, but they have no effect on aggregate stability**

Soil Density

- **Density** is the mass per unit volume of an object. by the unit $g.cm^{-3}$
- **Density= Mass / Volume**

Particle (Real or Actual) density

- **Particle density** :-

  is equal to the mass of solid particles divided by the volume of solid particles.

- **Particle density** = $\frac{\text{Mass of solid particles}}{\text{Volume of solid particles.}}$

Particle density

- It is the density of **only the mineral particles** that make up a soil; i.e., it excludes **pore space and organic material**.

- Soil particle density is typically **2.60 to 2.75 grams per cm^3** and is usually unchanging for a given soil.

- Soil particle density is **lower for soils with high organic matter** content, and is **higher for soils with high Fe-oxides content.**

Soil bulk density

- **Soil bulk density**

is equal to the dry mass of the soil divided by the volume of the soil; i.e., it includes air space and organic materials of the soil volume.(**$g.cm^{-3}$**)

Soil bulk density = Dry mass of the soil / Volume of the soil

Soil bulk density

* A high bulk density is indicative of either soil compaction or high sand content.

The bulk density of cultivated محروث loam is about 1.1 to 1.4 g/cm^3

(for comparison water is 1.0 g/cm^3)

***Soil bulk density is highly variable for a given soil.**

- **A lower bulk density by itself does not indicate suitability.**
- **For plant growth due to the influence of soil texture and structure.**
- **Soil bulk density is inherently أصلاً always less than the soil particle density.**

كةمترة ث / بوَضى هةردةم ضرِي ديار (الكثافةالظاهرية)

لة ضرِي رِاستةقينة (الكثافةالحقيقية)؟

Q/ Why the soil bulk density is less than particle density always time?

وةلاَم (10) نمرة