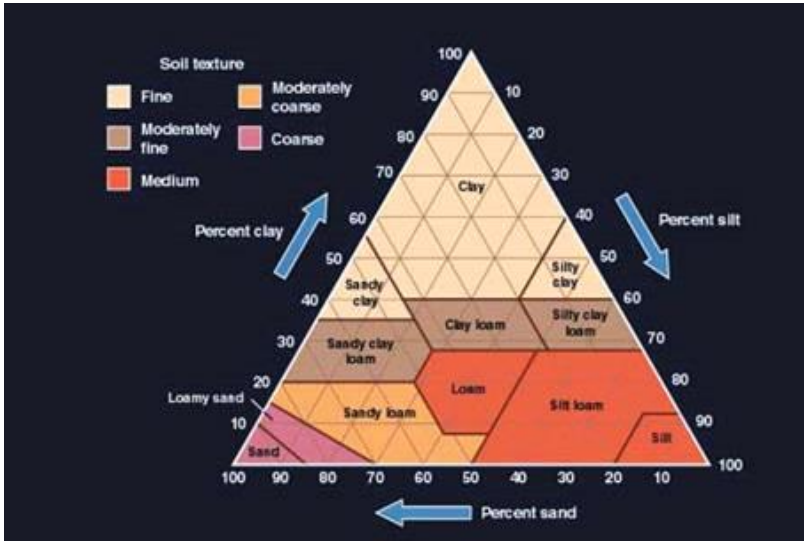
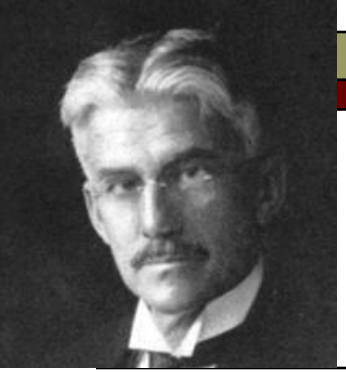
INTRODUCTION

- Plant growth is closely related to soil physical properties

- **Soil texture**



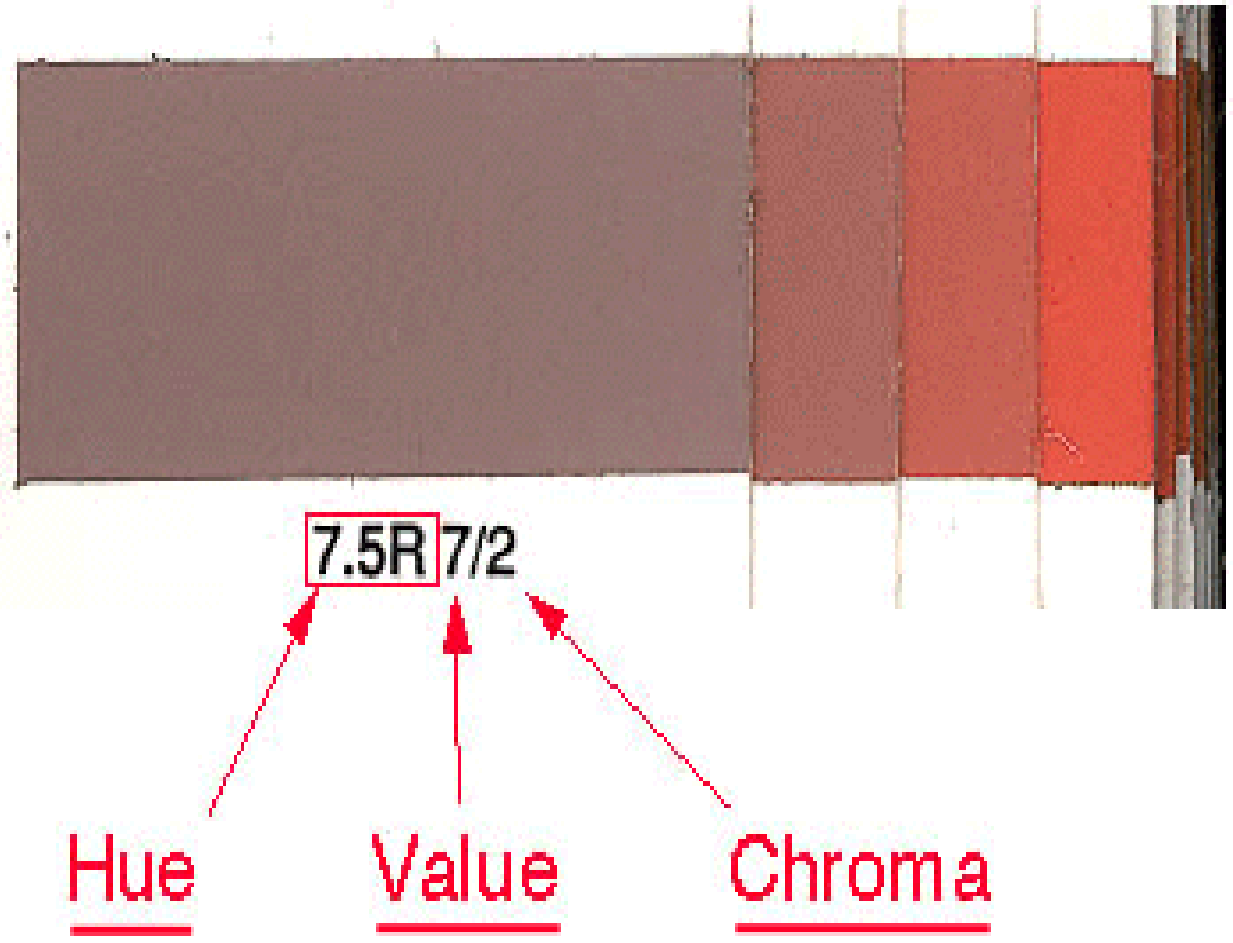
- **Soil structure**



SOIL COLOR

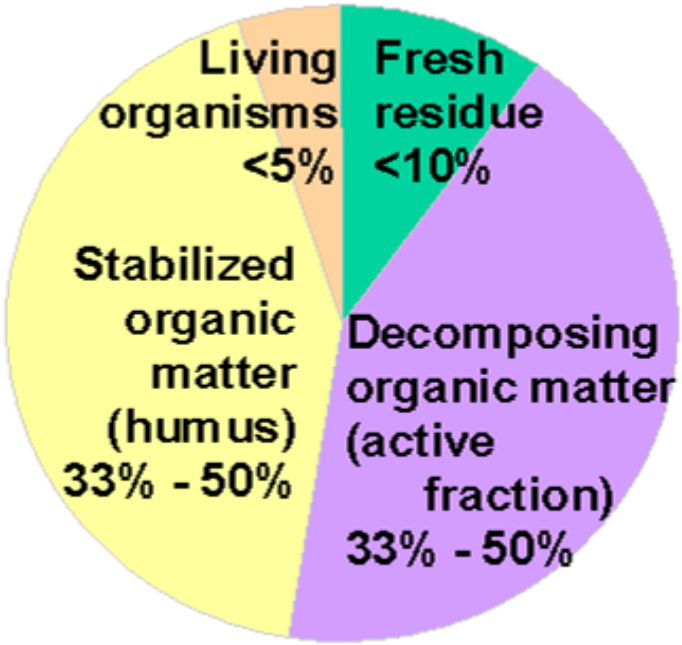
- Soil colors help explain the behavior and use of soils

- **Munsell color system** – standard system for accurate color description
  - **Hue** – redness or yellowness
  - **Chroma** – intensity or brightness (0=gray)
  - **Value** – lightness or darkness (0=black)


7.5R 7/2
Hue
Value
Chroma

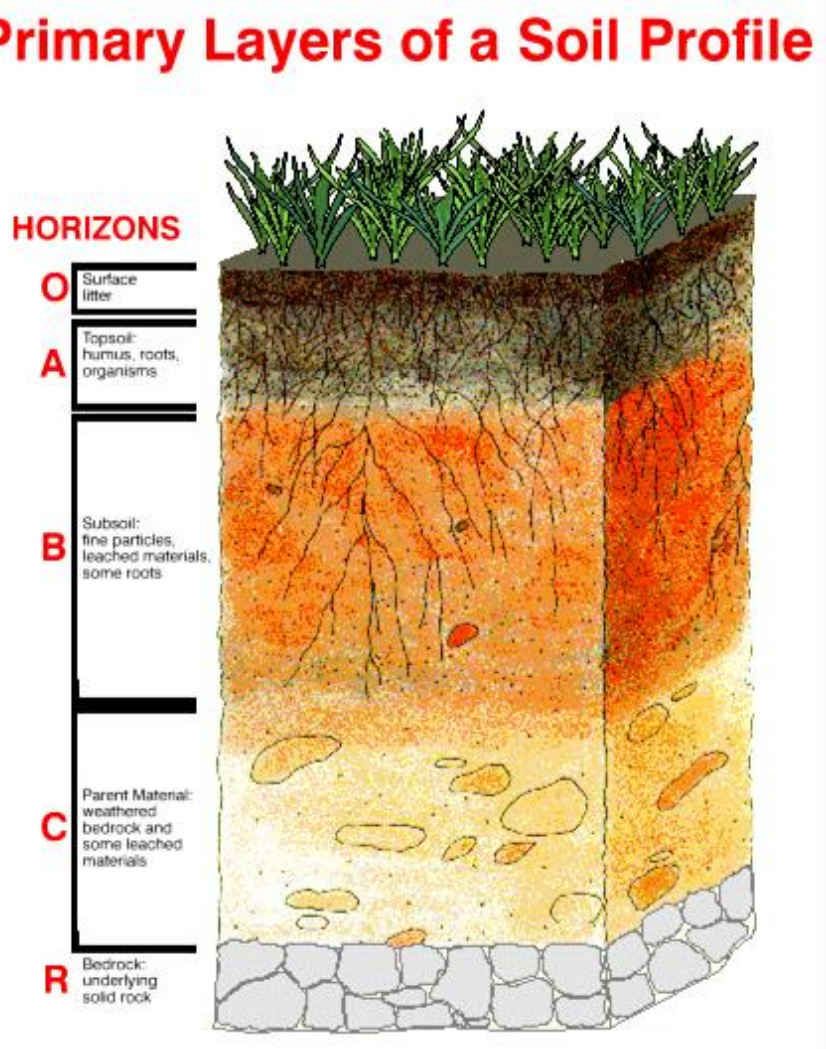
CAUSES OF SOIL COLOR

- **Organic matter**
  - Dark brown to black



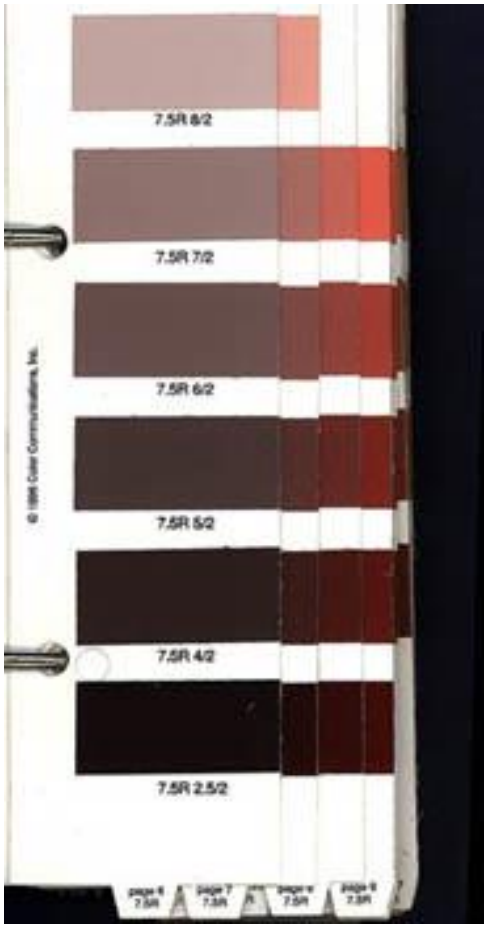
CAUSES OF SOIL COLOR

- **Water**
  - Wet soils darker than dry soils
  - Gray and bluish colors (low chroma)



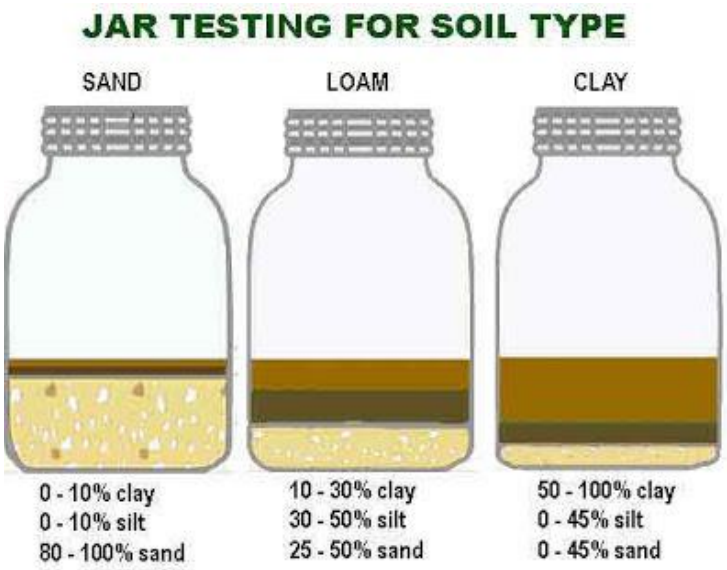
CAUSES OF SOIL COLOR

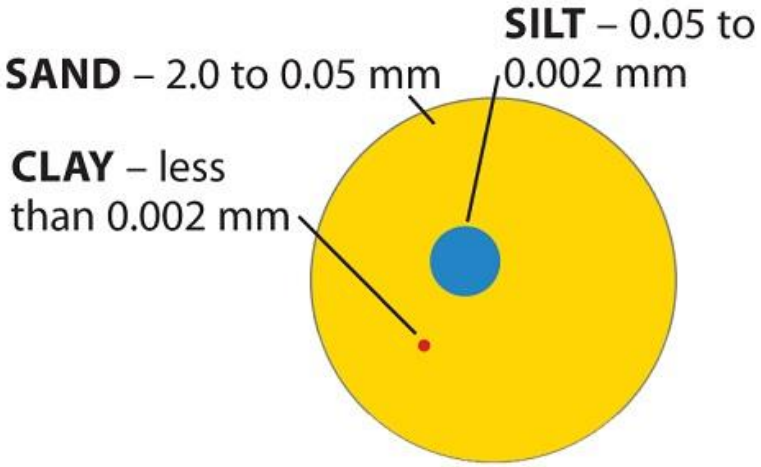
- Presence and oxidation state of iron and manganese oxides
  - **Iron** – reds and browns (high chroma)
  - **Manganese** – black
  - **Glauconite** – green
  - Calcite - white

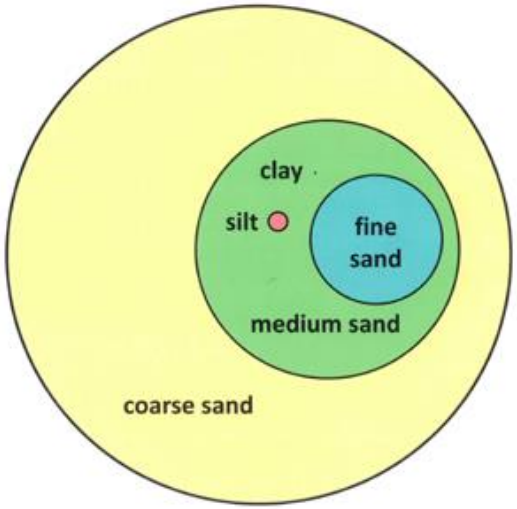


SOIL TEXTURE

- **Soil separates**







SOIL TEXTURE

- **Coarse fragments** – > 2 mm. in diameter
  - Gravels (2 – 75 mm)
  - Cobbles (rounded) (75-250 mm)
  - Flags (flat)
  - Boulders (> 250 mm)

COURSE FRAGMENTS

SAND

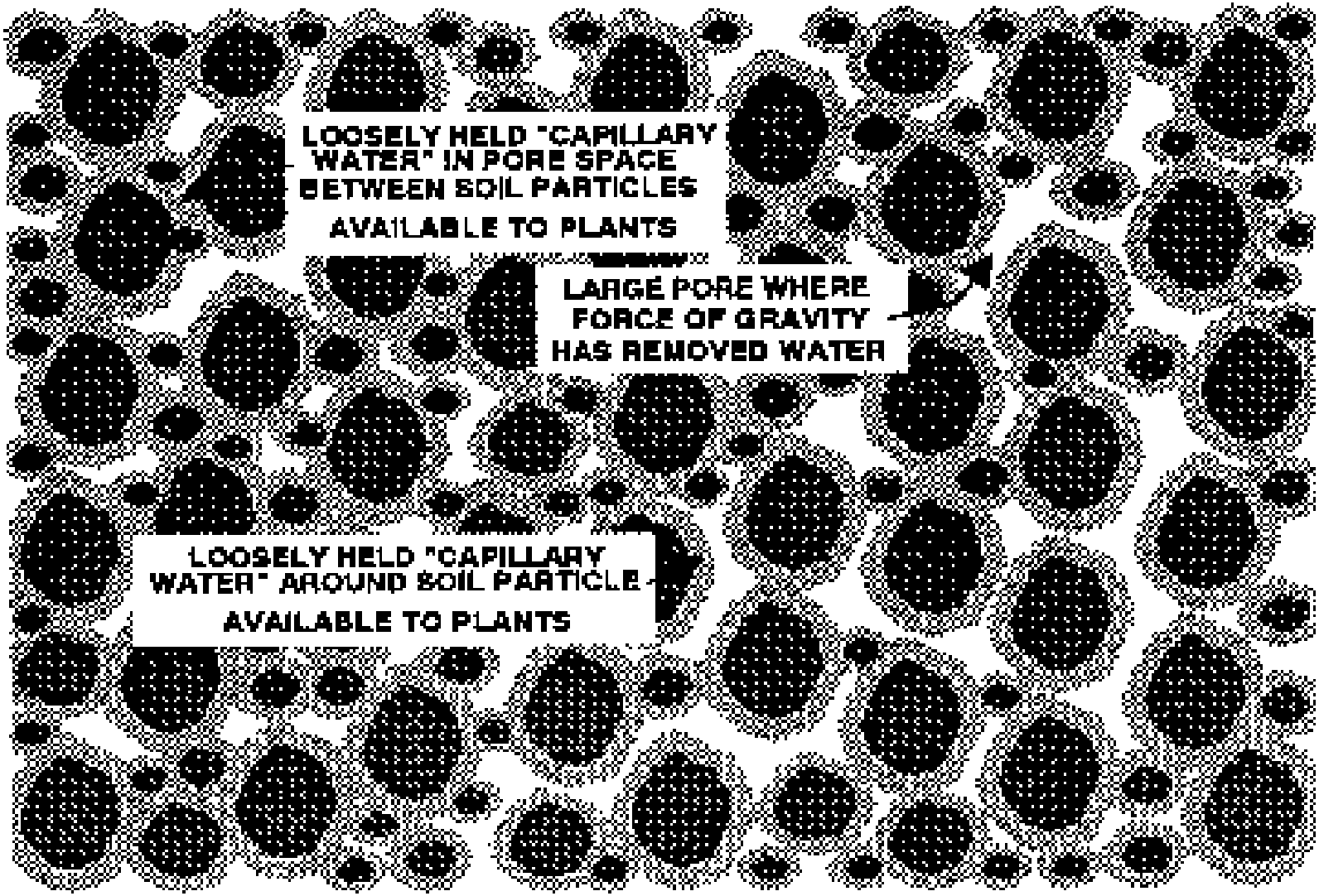
- 0.05 – 2 mm. in diameter
- Rounded or angular
- Feels gritty
- Particles are visible
- **Free drainage of water and entry of air**
- Low specific surface area
- **Prone to drought**

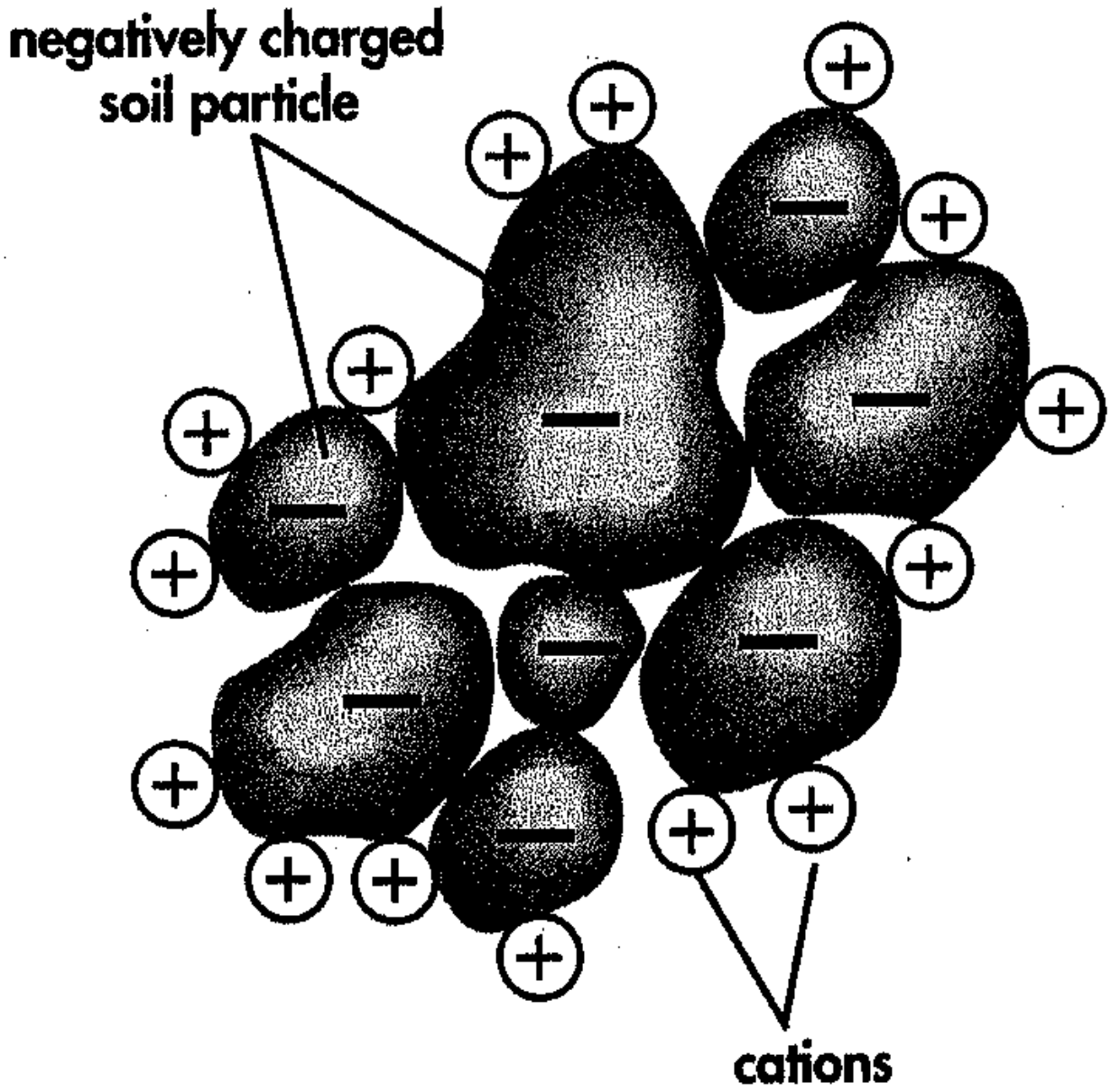
SILT

- 0.002 – 0.05 mm. in diameter
- Not visible to the naked eye
- Feels smooth or silky, but not gritty
- Quartz is dominant
- **Fertile**
- Good water retention
- Not sticky or plastic when wet

CLAY

- <0.002 mm in diameter
- **Poorly drained**
- Movement of air and water is slow
- **Sticky or plastic when wet**
- Very fertile
- Easily compacted

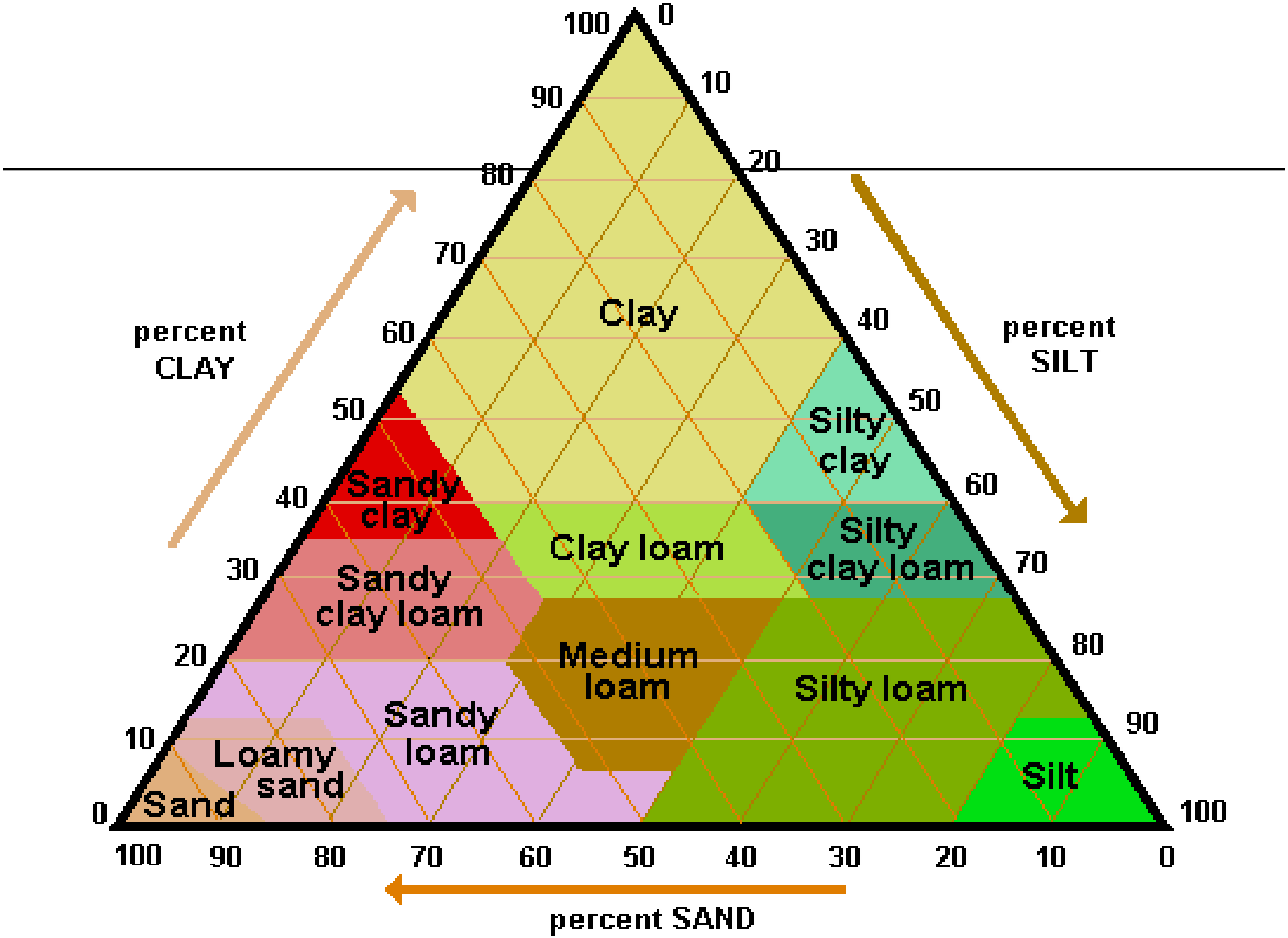

LOOSELY HELD "CAPILLARY WATER" IN PORE SPACE BETWEEN SOIL PARTICLES
AVAILABLE TO PLANTS
LARGE PORE WHERE FORCE OF GRAVITY HAS REMOVED WATER
LOOSELY HELD "CAPILLARY WATER" AROUND SOIL PARTICLE
AVAILABLE TO PLANTS


negatively charged
soil particle
cations

SOIL TEXTURE

- **Textural classes convey:**
  - Size distribution of particles in soil
  - General physical properties of that soil

- 12 major textural classes


percent CLAY
percent SILT
percent SAND
Clay
Silty clay
Sandy clay
Clay loam
Silty clay loam
Sandy clay loam
Medium loam
Silty loam
Sandy loam
Loamy sand
Sand
Silt
100
90
80
70
60
50
40
30
20
10
0

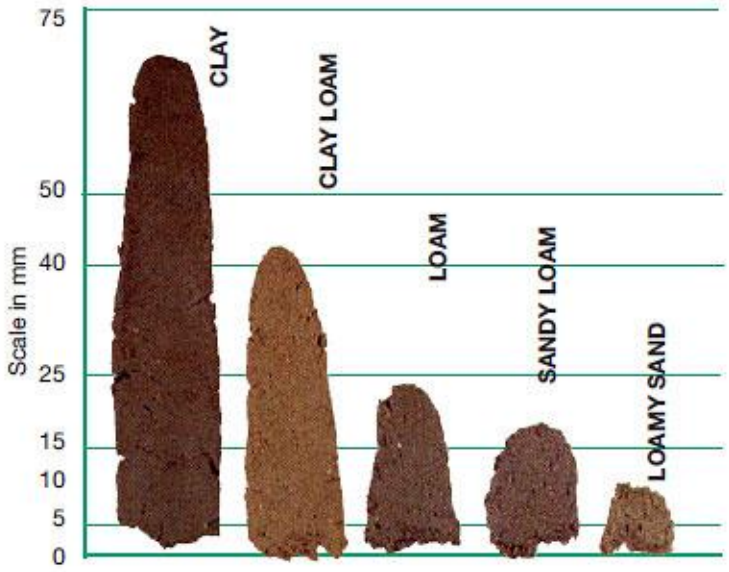
SOIL TEXTURAL CLASSES

- **Loam** – mixture of sand, silt, and clay in equal proportions
  - Sandy loam
  - Silt loams
  - Silty, clay loams
  - Sandy, clay loams
  - Clay loams

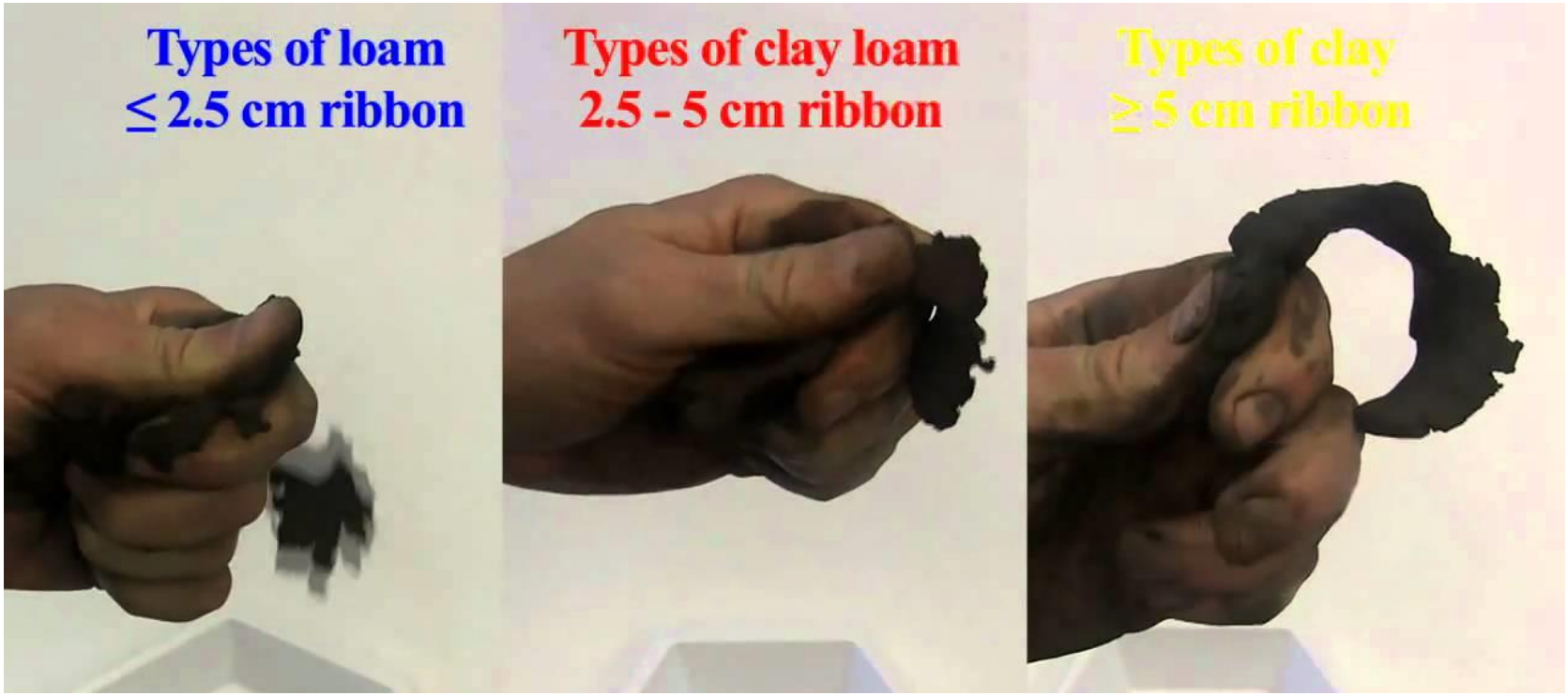
THE "FEEL" METHOD

- Rubbing a soil sample between thumb and fingers

- Important **field technique** for:
  - Soil surveys
  - Land classification
  - Soil texture

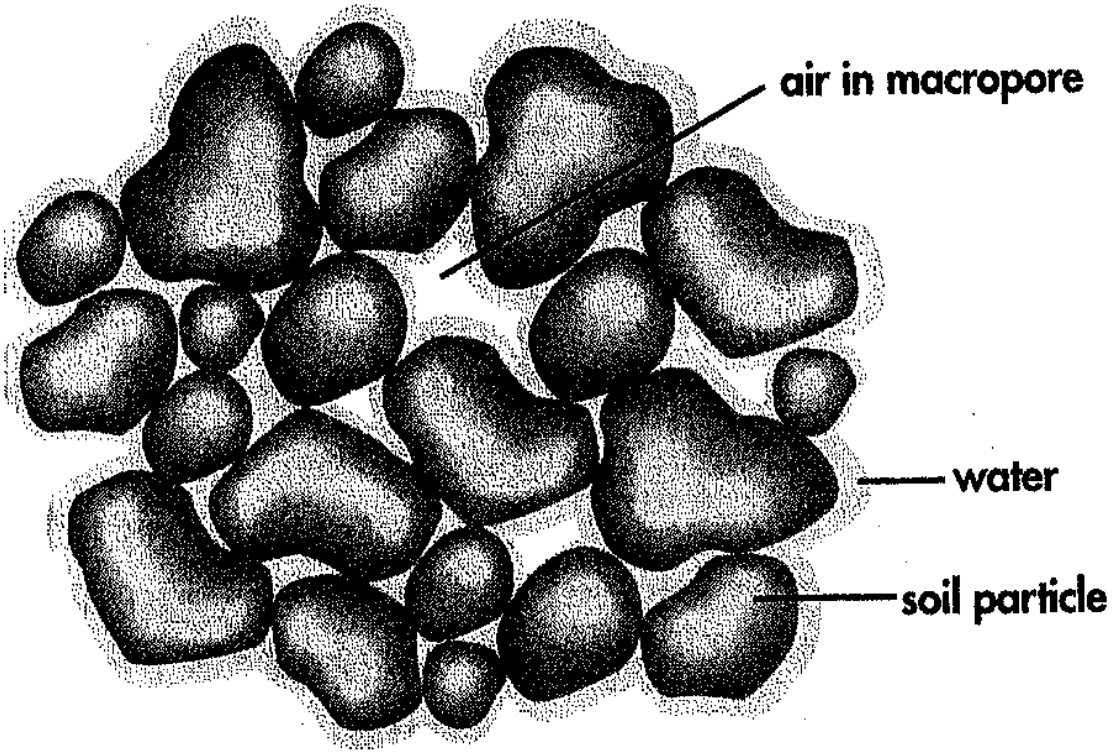


THE “RIBBON TEST”



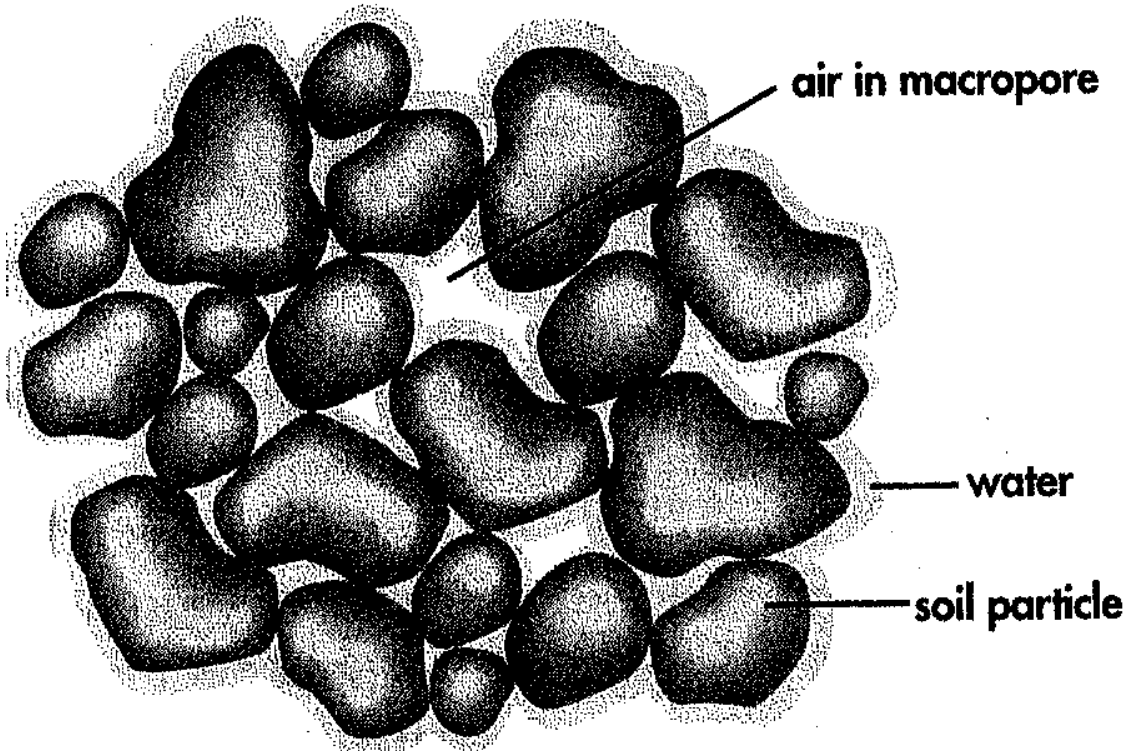
SOIL STRUCTURE

- **Structure** – arrangement of primary soil particles into groupings called **aggregates** or **peds**



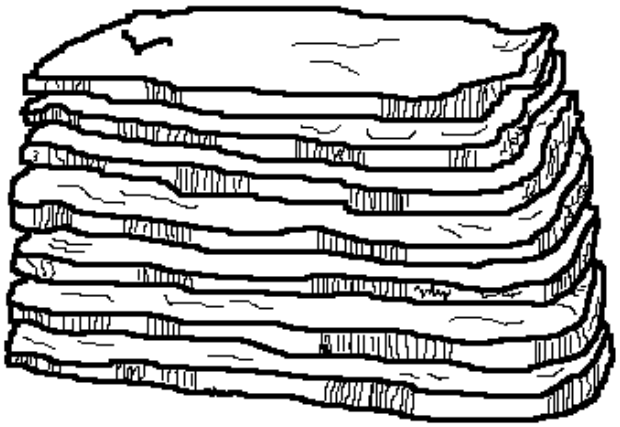
INFLUENCE OF STRUCTURE ON MINERAL SOILS

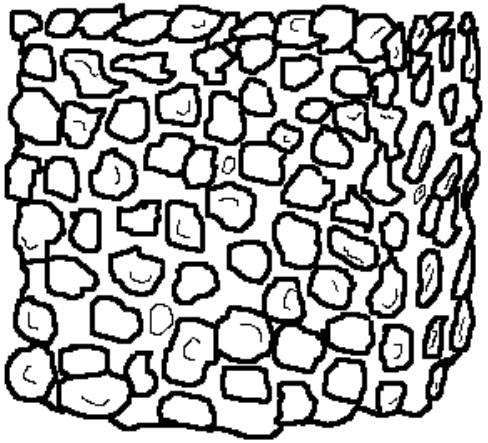
- Water movement
- Heat transfer
- Aeration
- **Soil porosity**

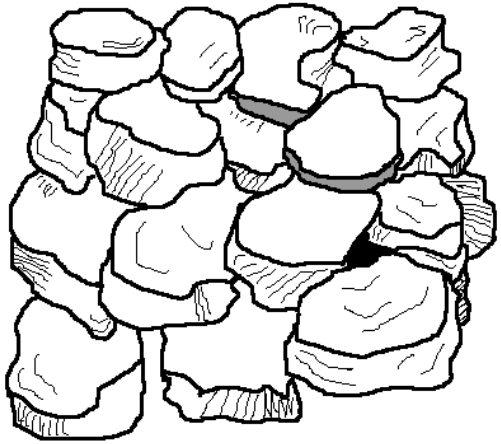


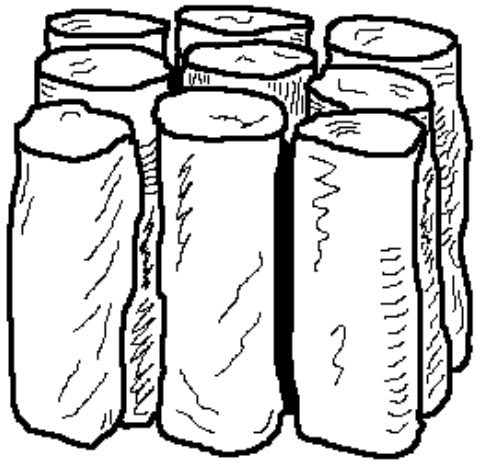
STRUCTURE OF MINERAL SOILS

- Spheroidal
- Platy



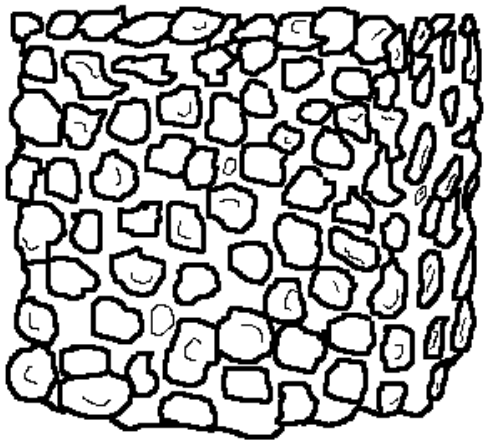


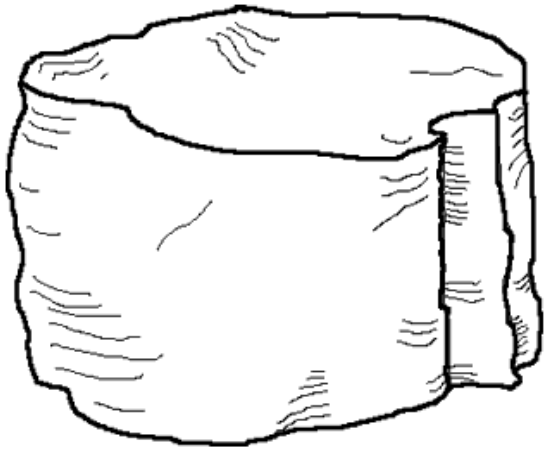


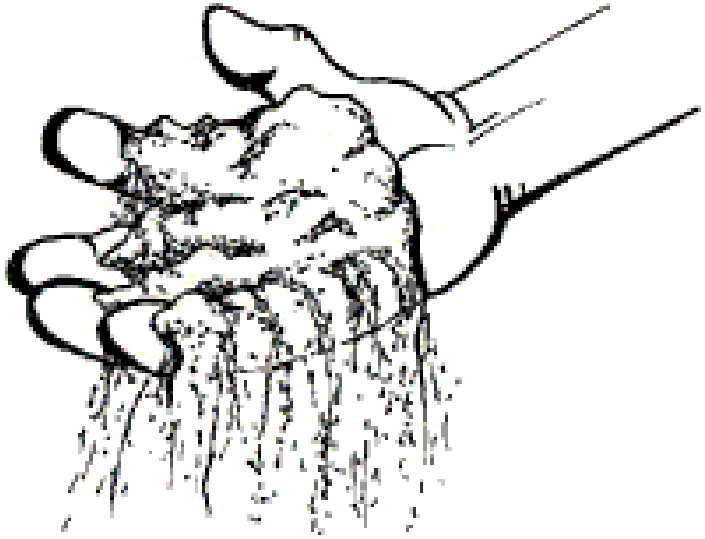


STRUCTURE OF MINERAL SOILS

- Prism-like
- Block-like
- No structure

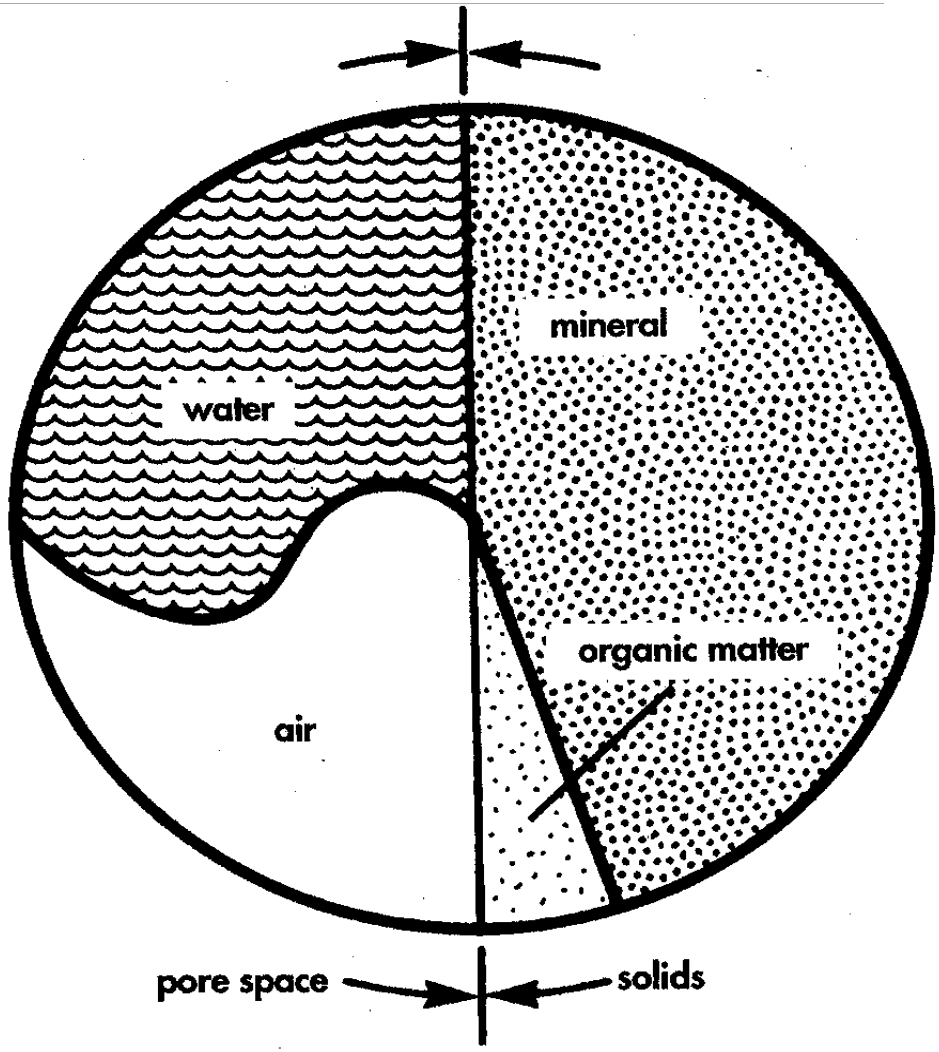






DESCRIBING SOIL STRUCTURE

- Size
- Fine
- Medium
- Coarse



SOIL PARTICLE DENSITY

- **The mass per unit volume of soil solids or specific gravity of a solid**

- Does not include soil volume which includes spaces between particles

SOIL BULK DENSITY

- **Mass of a unit volume of dry soil and includes both solids and pores**

- Methods for determining bulk density
  - Drying and weighing
  - Using a **coring instrument**

Comparison of Bulk Density and Particle Density

In a soil profile, one cubic centimeter ($1.0cm^3$) appears like this:

It contains solids and pore spaces, and the whole cm^3 has a mass of 1.32g.

To calculate **Bulk Density** of the soil:

Volume = $1.0cm^3$ (Solids and Pores)

Mass = 1.32g (Sieved Solids only)

$$\text{Bulk Density} = \frac{\text{Mass of Dry Soil}}{\text{Volume of soil (Solids and Pores)}}$$

Therefore:

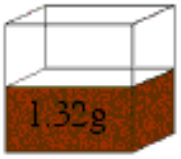
$$\textbf{Bulk Density} = \frac{1.32}{1.0} = 1.32\ g/cm^3$$

If all the solids were compressed to the bottom, the cube would now look like this:

Half contains the pore spaces →

Half contains the solids →

(Notice the Volume change!)



To calculate **Particle Density** of the soil:

Volume = **0.5**cm^3 **(Solids only)**

Mass = **1.32**g (Sieved Solids only)

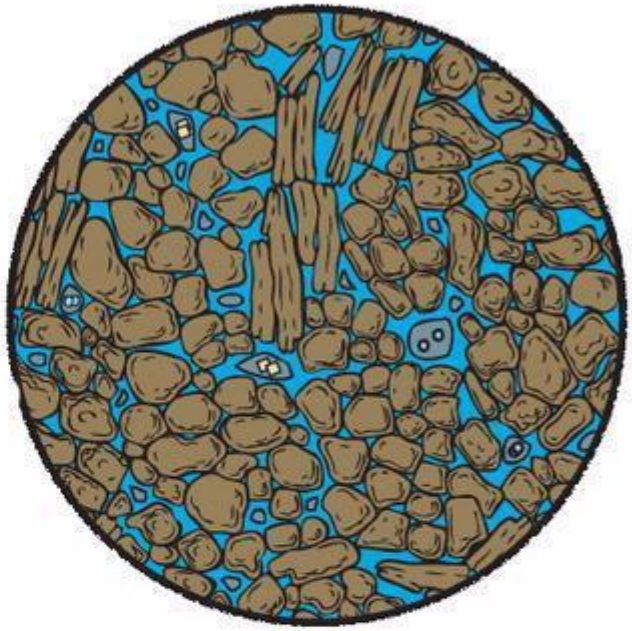
$$\text{Particle Density} = \frac{\text{Mass of solids (1.32g)}}{\text{Volume of solids (5cm}^3\text{)}}$$

Therefore:

$$\textbf{Particle Density} = \frac{1.32}{.5} = 2.64\ g/cm^3$$

SAMPLING FOR BULK DENSITY

Lower bulk density
Lower weight
More pore space



Higher bulk density
Higher weight
Less pore space

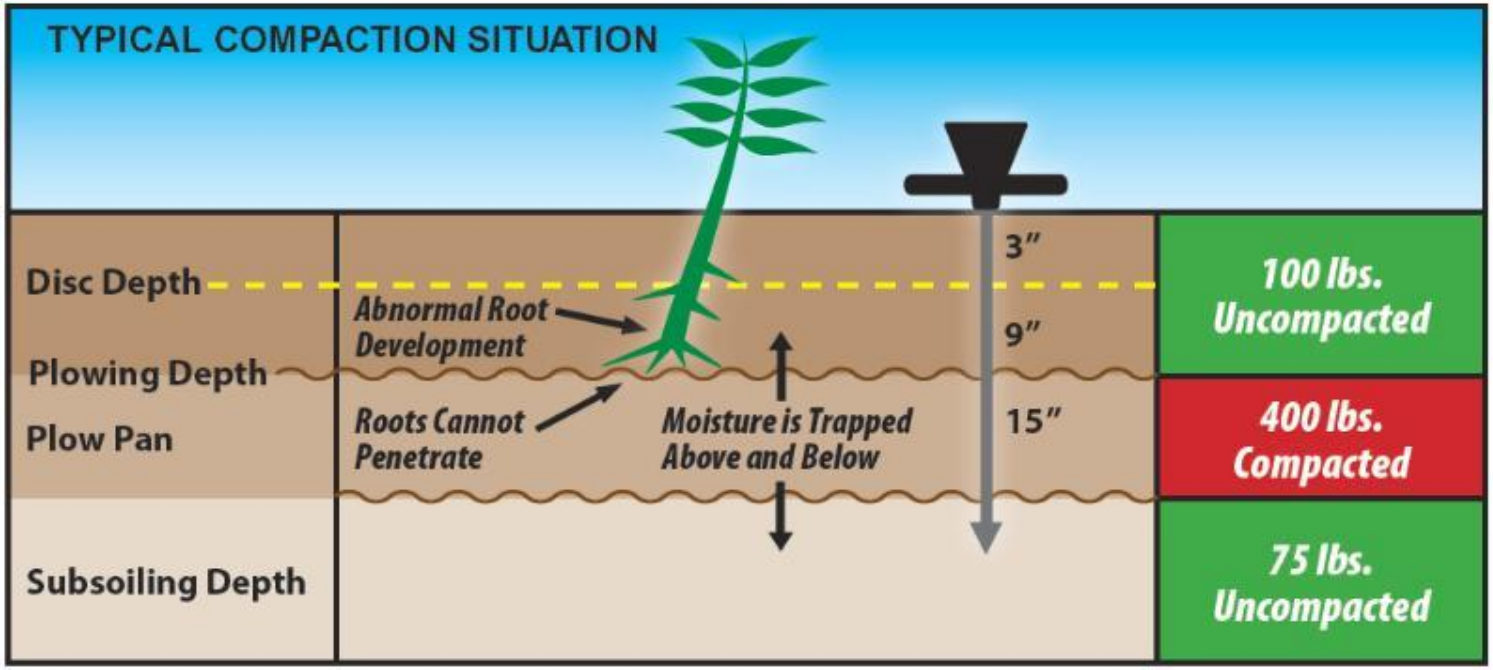
RELATIONSHIP OF SOIL BULK DENSITY TO ROOT GROWTH BASED ON SOIL TEXTURE

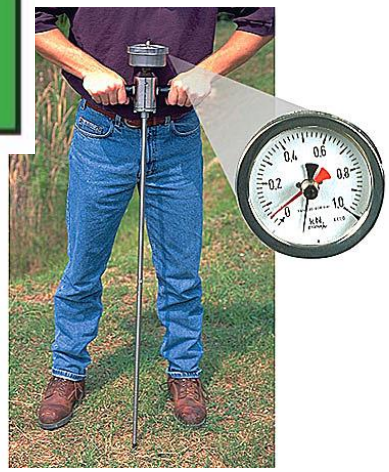
SOIL TEXTURE	IDEAL BULK DENSITIES FOR PLANT GROWTH (g/cm^3)	BULK DENSITIES THAT RESTRICT ROOT GROWTH (g/cm^3)
Sandy	<1.60	>1.80
Silty	<1.40	>1.65
Clayey	<1.10	>1.47

BULK DENSITIES AS A FUNCTION OF SOIL TEXTURE

TEXTURE	IDEAL BD (gm/cm3)	MAY EFFECT ROOT GROWTH	RESTRICTS ROOT GROWTH
Sands and loamy sands	<1.60	1.69	>1.80
Sandy loam, loams	<1.40	1.63	>1.80
Sandy clay loams, clay loams	<1.40	1.60	>1.75
Silts, silt loams	<1.30	1.60	>1.75
Silt loams, silty clay loams	<1.40	1.55	>1.65
Sandy clays, silty clays	<1.10	1.49	>1.58
Clays	<1.10	1.39	1.47

EFFECTS OF SOIL COMPACTION





EFFECTS OF SOIL COMPACTION

FACTORS AFFECTING BULK DENSITY

- **Pore space**
  - Soils with greater pore space have lower bulk density
- **Soil texture**
  - Fine textures soils have lower bulk densities than sandy soils
- **Depth in soil profile**
  - **Compacted soils have BD's > 2.0 mg/m^3**

MANAGEMENT PRACTICES AFFECTING BULK DENSITY

- **Forest lands**
  - Very sensitive to increases in BD

- **Urban areas**
  - Involved severely compacted soils

MANAGEMENT PRACTICES AFFECTING BULK DENSITY

MANAGEMENT PRACTICES AFFECTING BULK DENSITY

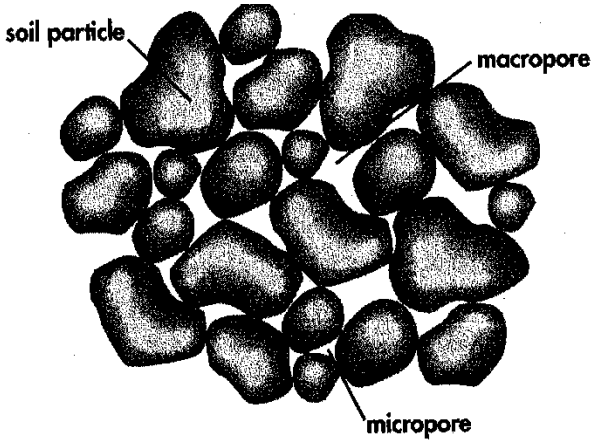
- **Landscapes**
  - Mowing and vehicle traffic can increase bulk density
  - **Plow pan (traffic pan)** – dense zones just below plow level
  - **Sub-soiling** – used to break up plow pan layers
  - **Core aerifying** helps breaks up surface soils

SOIL STRENGTH

- **Soil strength** – soil property that causes it to resist deformation
  - Measured using a **penetrometer**
  - Higher in dry soils

TYPES OF PORES

- **Macropores** > 0.08 mm.
  - Allow ready movement of air and water drainage
  - Accommodate plant roots and tiny animals
  - Found between peds (**interped pores**)



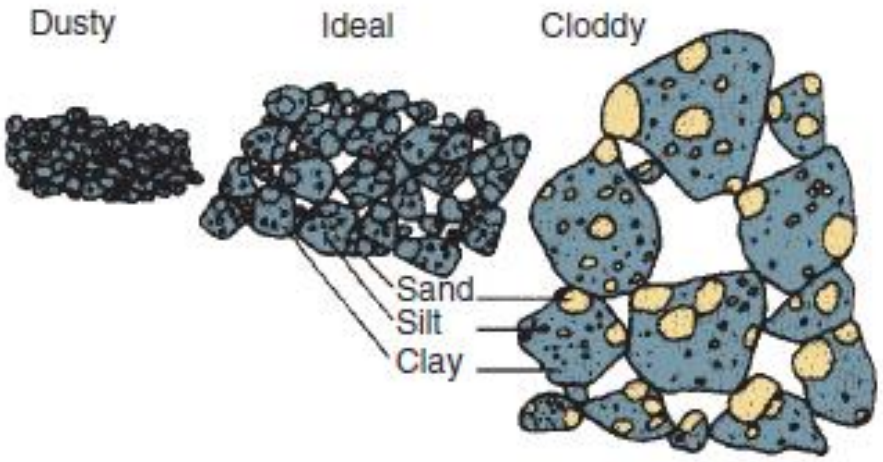
- **Micropores** < 0.08 mm.
  - Filled with water
  - Too small to permit air movement
  - Water retained in these pores is **unavailable** to plants

TYPES OF PORES

- **Biopores** – created by roots, earthworms, and other organisms

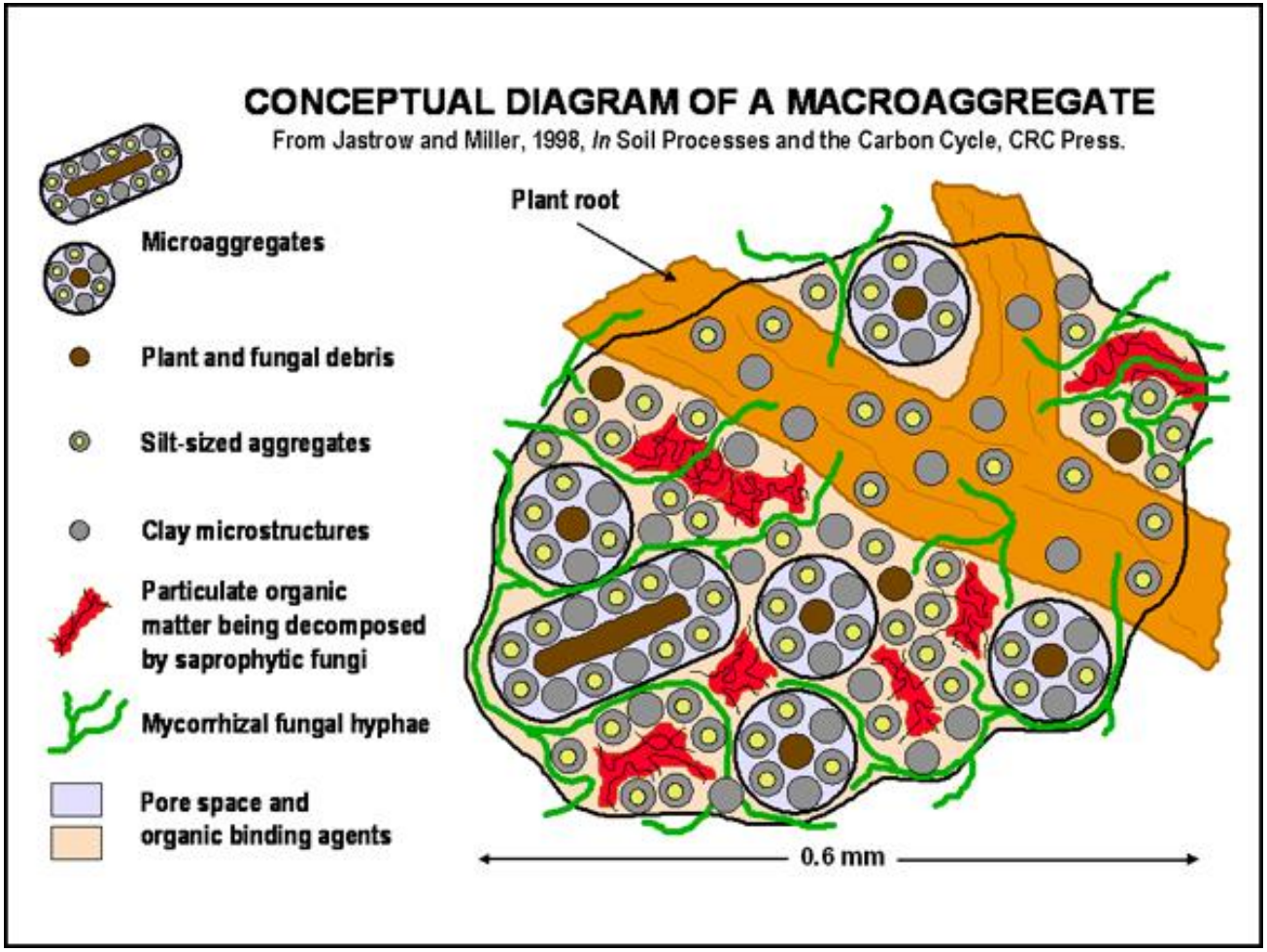
SOIL AGGREGATES

- Large structural **aggregates** provide for:
  - Low bulk density
  - High proportion of macropores



- Smaller aggregates are more stable than larger ones

MACRO-AGGREGATES



BIOLOGICAL PROCESSES IMPACTING AGGREGATES

- Earthworms
- Roots and fungal hyphae
- Organic glues produced by micro-organisms
- Organic matter

TILLAGE AND SOIL TILTH

- **Tilth** – the physical condition of the soil in relation to plant growth

- **Soil tilth depends on**:
  - Aggregate formation and stability
  - Bulk density
  - Degree of aeration
  - Drainage
  - Soil moisture content
  - Rate of water infiltration
  - Capillary water capacity

GUIDELINES FOR MANAGING SOIL TILTH

- Timing of traffic activities
- Mulching soil surface
- Applying gypsum

END OF PRESENTATION