GEOL 408/508

INTRODUCTORY SOILS

Lecture = 3 hrs/week
Lab = 3hrs/week
Course = 4 credits

Name/Define the Following

1. N_2
2. NH_3
3. NH_4^+
4. NO_2^-
5. NO_3^-
6. protein
7. organics
8. organic matter
9. P
10. PO_4^{-3}
11. Cl_2
12. Cl^-

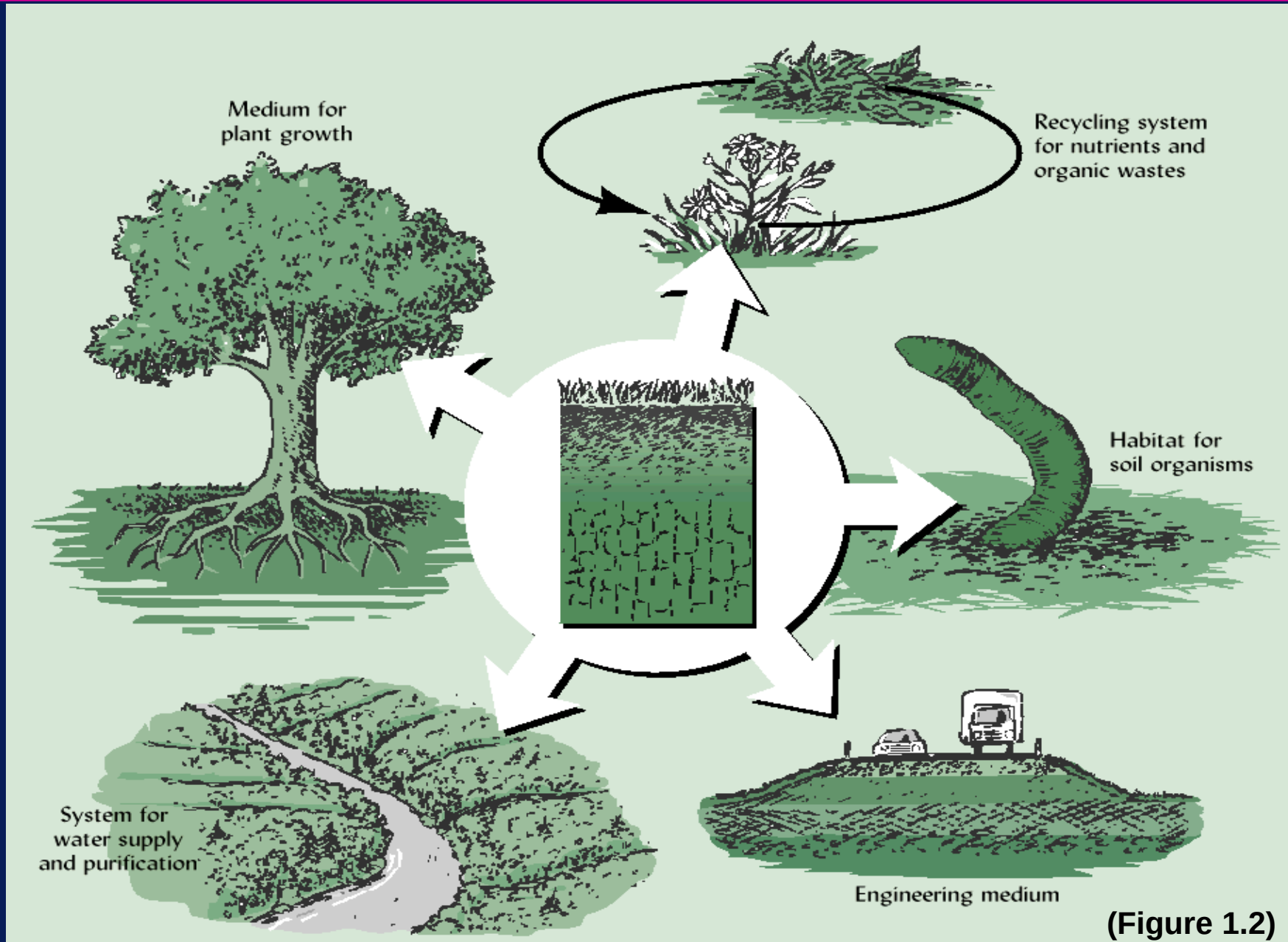
GEOL 408/508

THE SOILS AROUND US

Chapter 1

Brady and Weil, Revised 14th Ed.

ECOLOGICAL ROLES OF SOIL FUNCTIONS



(Figure 1.2)

MEDIUM FOR PLANT GROWTH

- soil provides physical support
- soil pores provide ventilation
- water holding capacity extremely important
- soil moderates temperature fluctuations
- provides source for inorganic mineral nutrients
- of the 92 naturally occurring elements, 18 have been shown to be essential
- may be source of phytotoxic elements

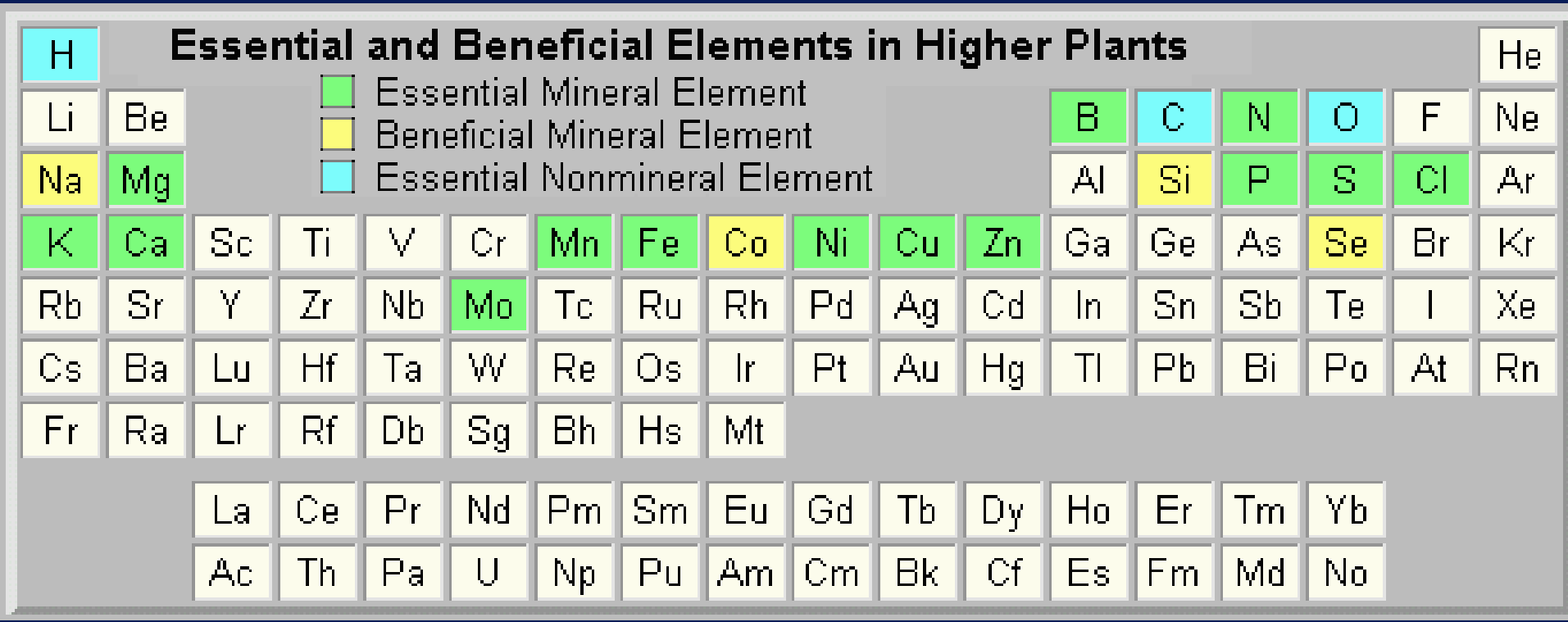
THE 18 ESSENTIAL ELEMENTS

- **These three come from carbon dioxide (CO_2) and water (H_2O), and are not considered mineral nutrients.**
  - **Carbon**
  - **Hydrogen**
  - **Oxygen**

THE 15 ESSENTIAL MINERALS

- These are absorbed by plant roots
- Those required in large quantities:
  - Macronutrients
    - Primary
    - Secondary
- Those required in limited quantities:
  - Micronutrients

ESSENTIAL ELEMENTS LOCATED IN THE PERIODIC TABLE



MACRONUTRIENTS

- **Primary** - needed in largest amounts
  - Nitrogen N
  - Phosphorus P
  - Potassium K
- **Secondary** - needed in lesser amounts
  - Calcium Ca
  - Sulfur S
  - Magnesium Mg

MICRONUTRIENTS

- **Always classified as essential:**
  - **Iron** **Fe**
  - **Zinc** **Zn**
  - **Manganese** **Mn**
  - **Copper** **Cu**
  - **Boron** **B**
  - **Molybdenum** **Mo**
  - **Chloride** **Cl**
- **Sometimes considered essential:**
  - **Cobalt** **Co**
  - **Nickel** **Ni**

REGULATOR OF WATER SUPPLIES

- soil cover important - vegetation
- soil infiltration important - soil structure
- soil content of fertilizers - water quality
- soil texture/mineralogy - water quality

RECYCLER OF RAW MATERIALS

- assimilate organic matter, turning it into humus
- convert mineral nutrients in wastes into useable forms
- return C as CO_2 to the atmosphere
  - reused by plants
  - greenhouse gas
- sequester C in soil as organic matter
  - reduces greenhouse gas levels

HABITAT FOR SOIL ORGANISMS

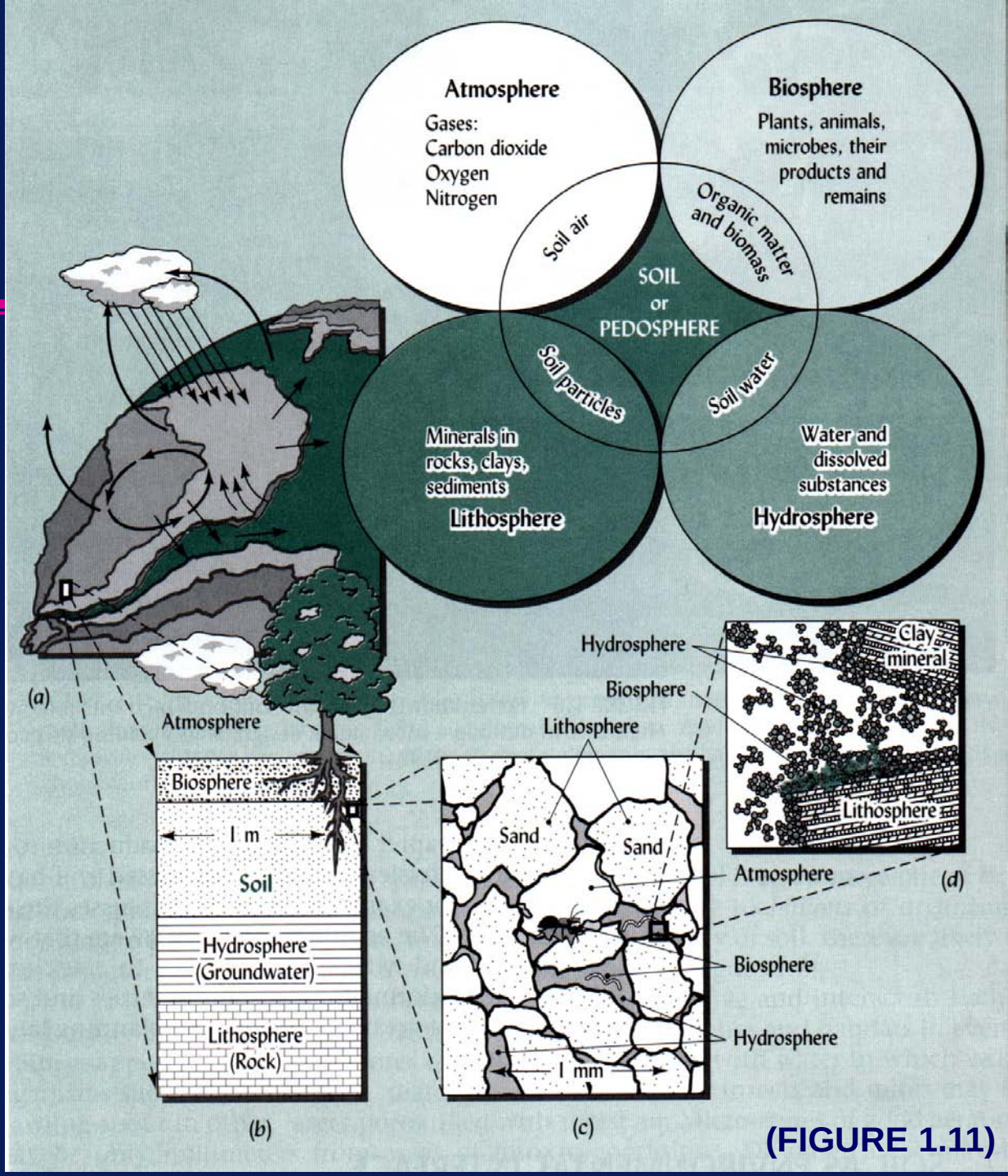
- complex communities of organisms
- tremendous range of niches and habitats
- interrelationship between organism groups
- perform numerous beneficial tasks

ENGINEERING MEDIUM

- soil properties highly variable
- desirable properties vary for different needs
- requires appropriate knowledge to
  - choose best soil
  - modify soil properties
  - modify structures to accommodate soil properties

SOIL AS ENVIRONMENTAL INTERFACE

Concept of Pedosphere



(FIGURE 1.11)

SOIL AS A NATURAL BODY

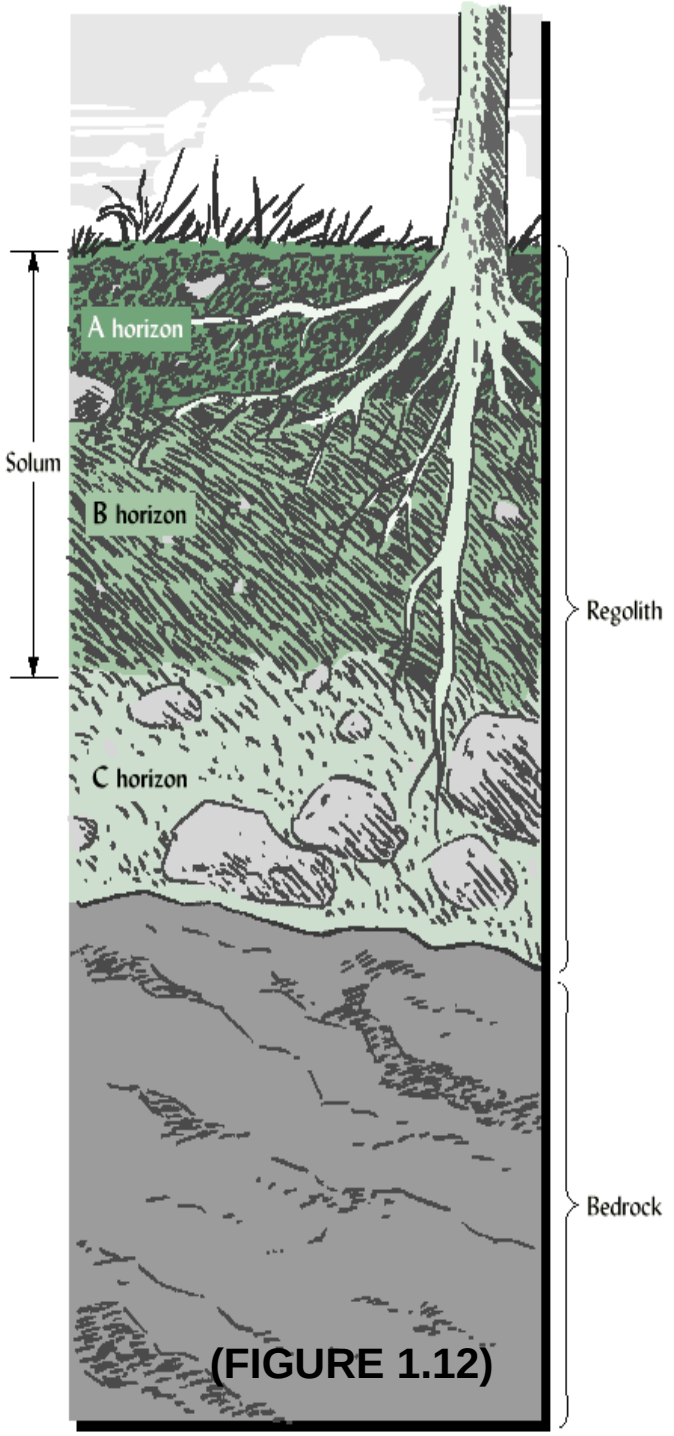
- ***the soil*** **versus** ***a soil***
- **a three-dimensional natural body**
- **so, what really is soil?**
- **a natural body consisting of layers or horizons of mineral and/or organic constituents of variable thicknesses, which differ from the parent material in their morphological, physical, chemical and mineralogical properties and their biological characteristics.**

Relative positions of the regolith, its soil, and the underlying bedrock.

Note that the soil is a part of the regolith, and that the A and B horizons are part of the solum (from the Latin word solum, which means soil or land).

The C horizon is the part of the regolith that underlies the solum, but may be slowly changing into soil in its upper parts.

Sometimes the regolith is so thin that it has been changed entirely to soil; in such a case, soil rests directly on the bedrock.



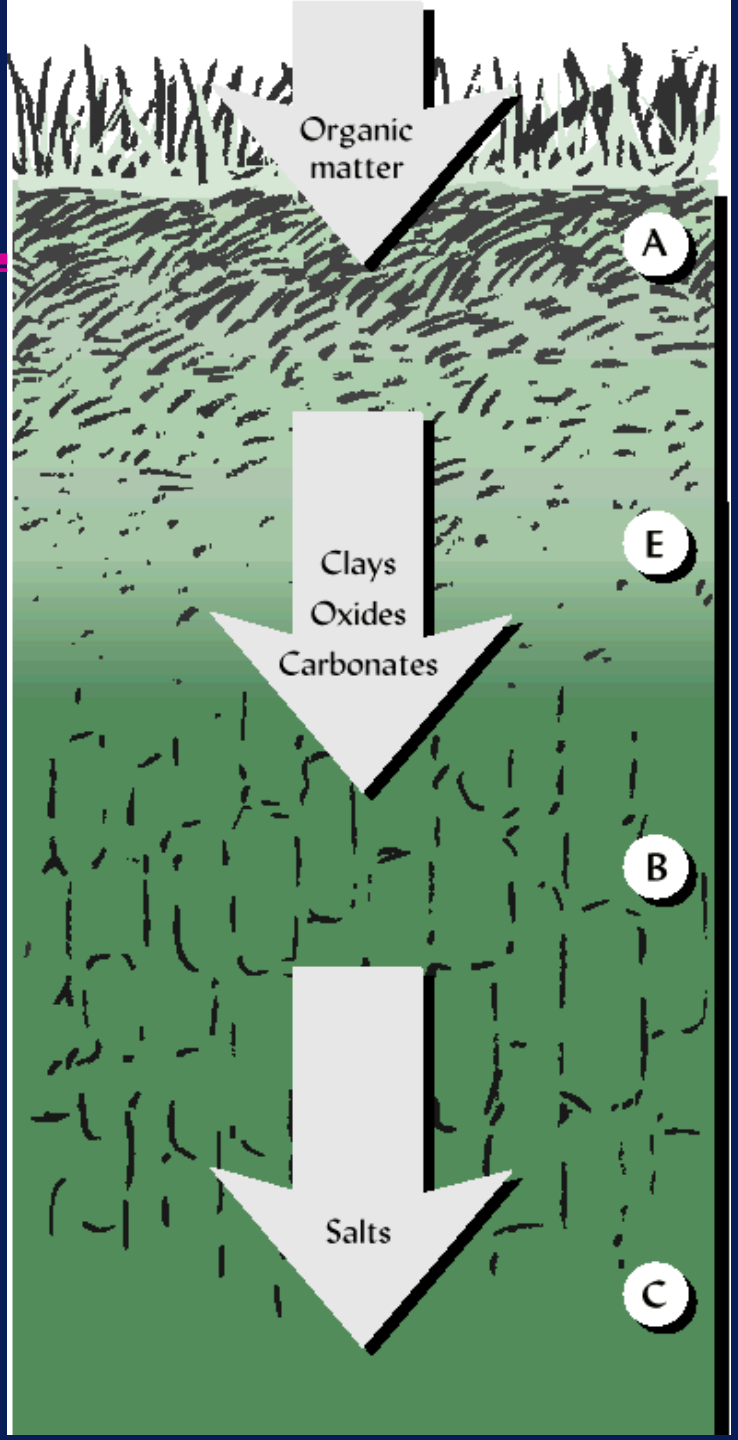
(FIGURE 1.12)

HORIZON DIFFERENTIATION

Horizons begin to differentiate as materials are added to the upper part of the profile and other materials are translocated to deeper zones.

Under certain conditions, usually associated with forest vegetation and high rainfall, a leached E horizon forms between organic-matter-rich A and the B horizons.

If sufficient rainfall occurs, soluble salts will be carried below the soil profile, perhaps all the way to the groundwater. (FIGURE 1.14)



PRIMARY SOIL HORIZONS

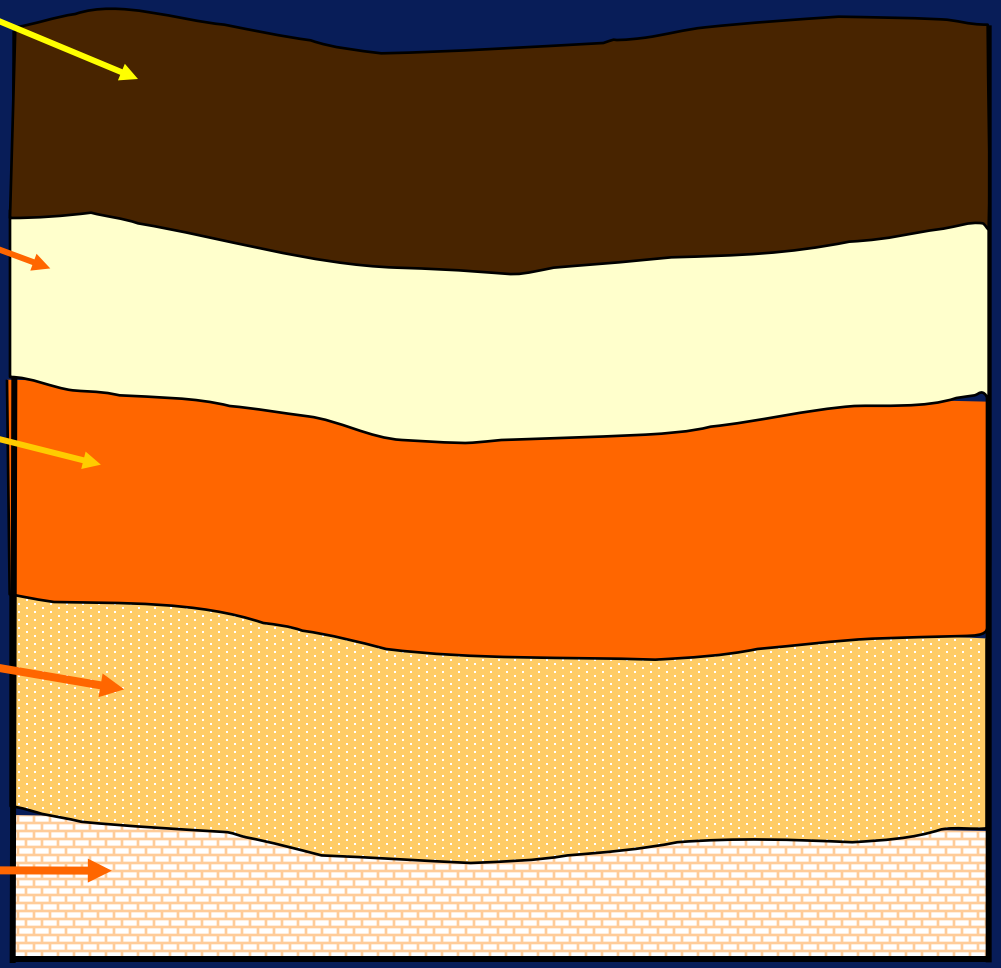
A Horizon
Organic rich
Highest organism activity

E Horizon
Zone of leaching, eluviation

B Horizon
Weathered,
Accumulation of
Clays, oxides

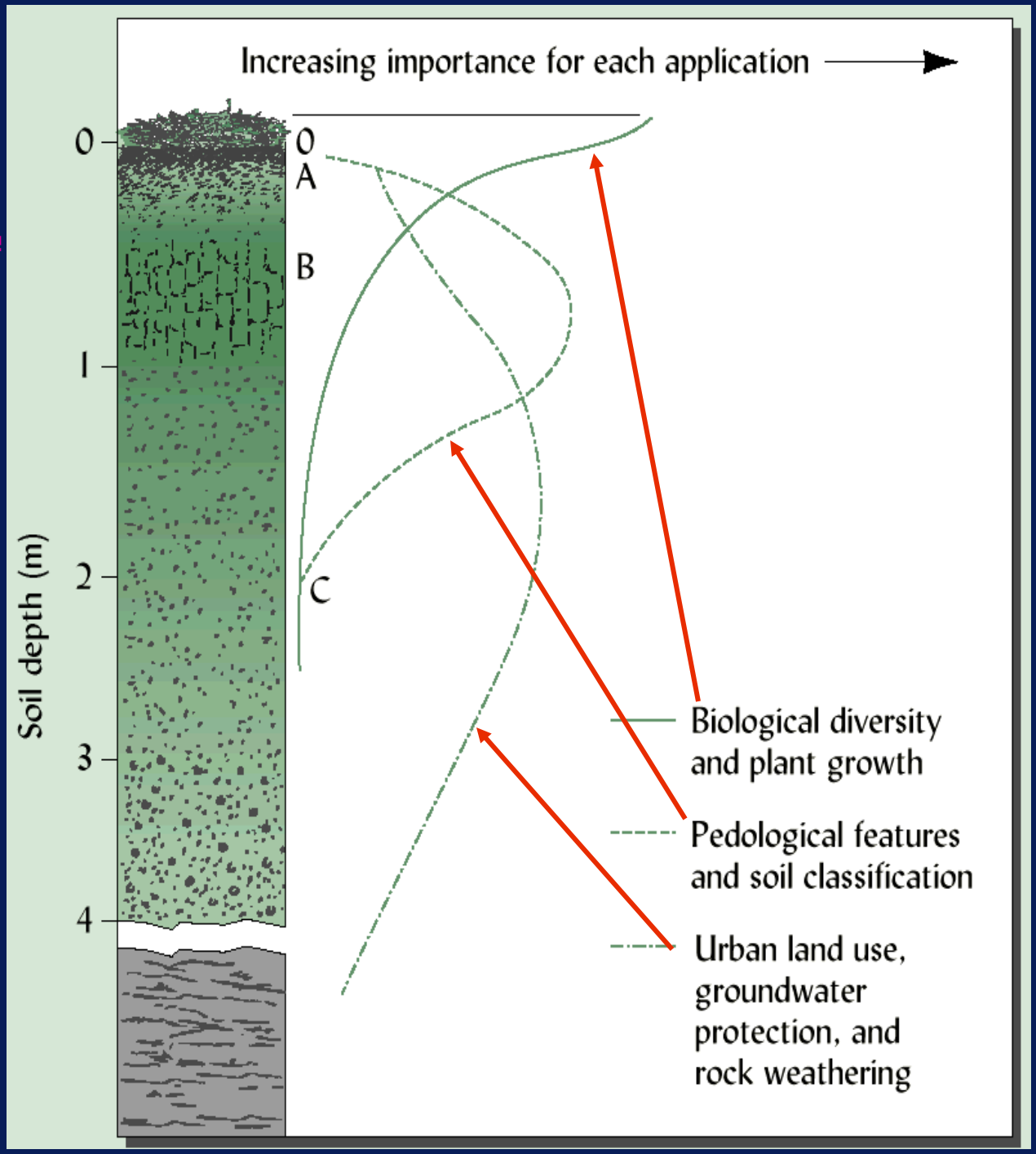
C Horizon
Parent Material;
May be multiple layers

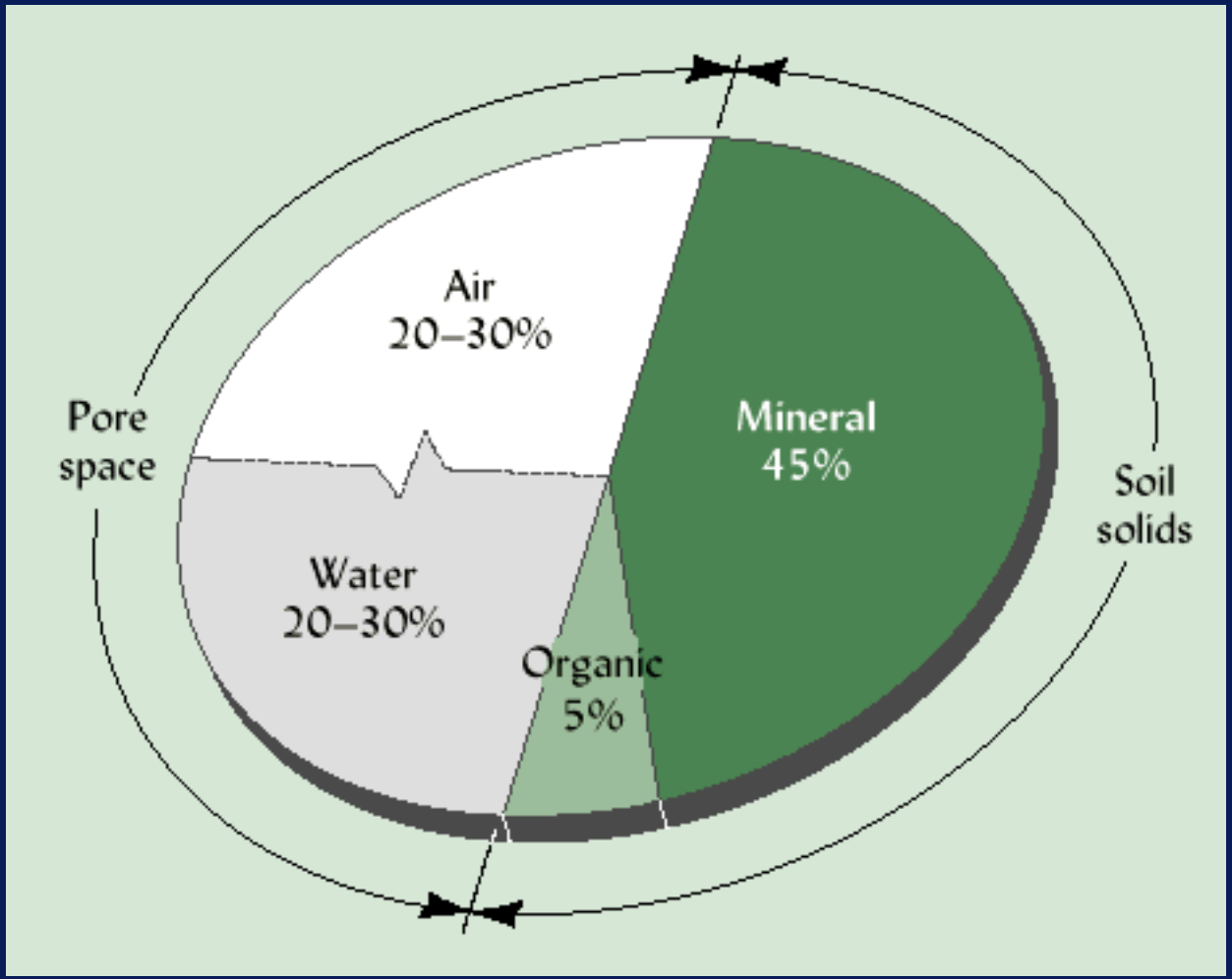
R Horizon
Bedrock
In Hampton Roads:
2000 ft deep



SOIL HORIZONS AND SOIL FUNCTIONS

Information important to different soil functions and applications is most likely to be obtained by studying different layers of the soil profile.
(FIGURE 1.17)





Volume composition of a loam surface soil when conditions are good for plant growth. The broken line between water and air indicates that the proportions of these two components fluctuate as the soil becomes wetter or drier. Nonetheless, a nearly equal proportion of air and water is generally ideal for plant growth. (FIGURE 1.18)

MINERAL (INORGANIC) CONSTITUENTS OF SOILS

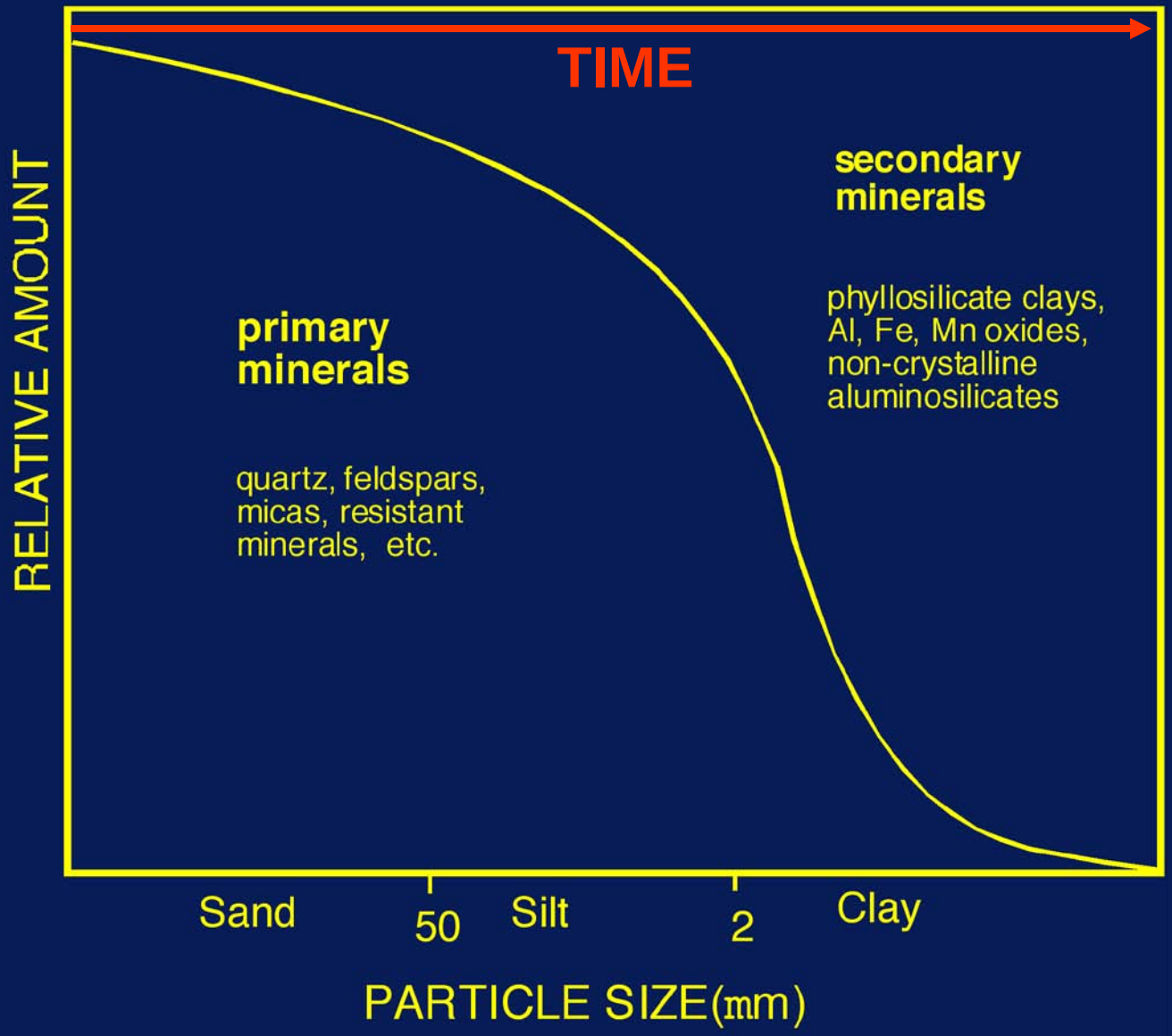
Mineral soil particles:

Sand - (coarse particles):
50 to 2000 micrometers (μm) diameter

Silt - (medium sized particles):
2 to 50 μm diameter

Clay - (fine particles):
< 2 μm diameter

RELATIVE ABUNDANCE OF PRIMARY AND SECONDARY MINERALS



SOIL ORGANIC MATTER

- Living soil organisms
  - invertebrates
  - bacteria & fungi
- Plant roots
- Decomposing dead organic matter
- Humus (highly decomposed organic matter)
- Transitory component - continually being decomposed, thus must constantly be renewed

SOIL ORGANIC MATTER (CONT)

Functions:

- granulator of soil particles into aggregates
- major source of P and S
- increases water holding capacity
- primary source of energy for microorganisms
- major “sink” for chemicals, nutrients & contaminants

SOIL WATER

- Dynamic (solution) component
  (in balance with soil air)

- held in soil pores with varying strength,
  the less present, the stronger held

- water plus dissolved salts = soil solution

- soil solution:
  - in equilibrium with solid components
  - pH is important property

SOIL WATER pH

$$pH = \log\left(\frac{1}{[H^+]}\right)$$

or:

$$pH = - \log [H^+]$$

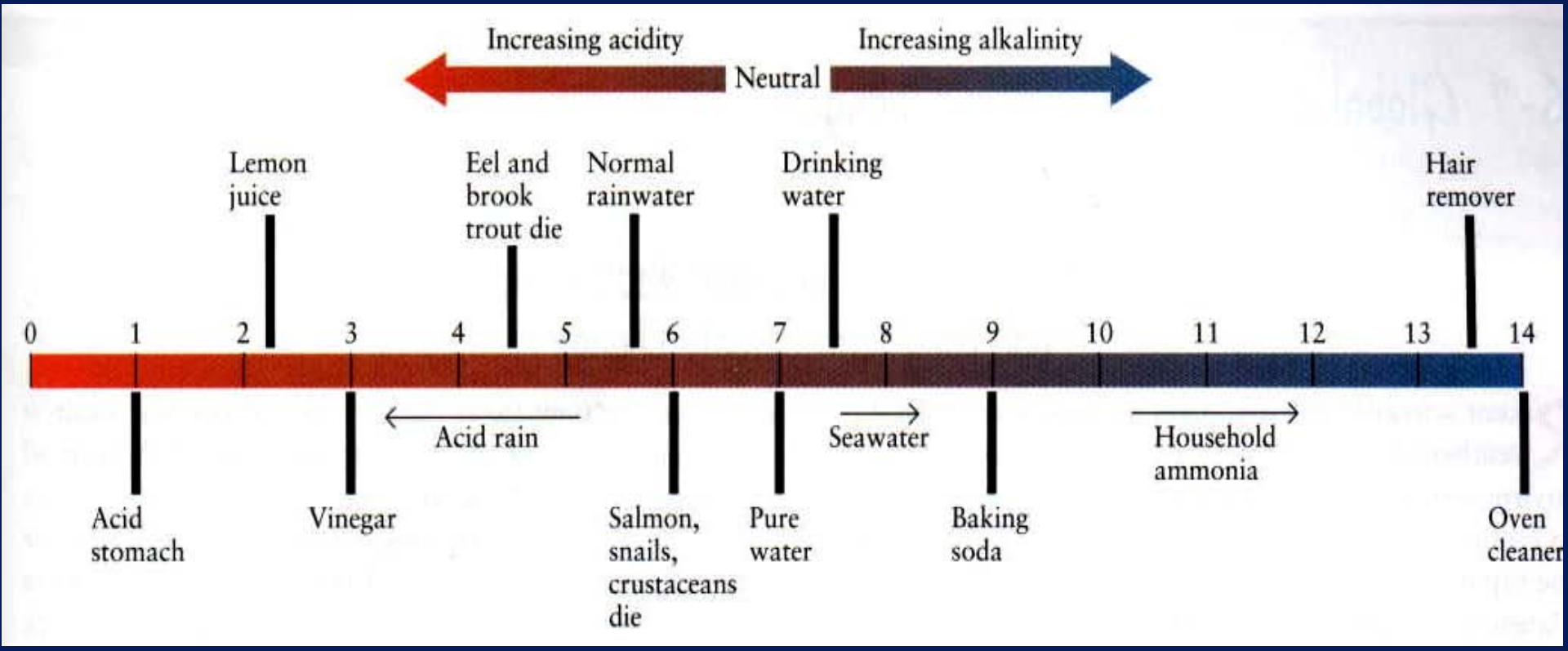
Example:

$[H^+] = 0.001$ or 10^{-3} *M*, pH = 3

[H+] = 10 or 10^{1} *M*, pH = -1

pH scale on instruments is 0 to 14 - why?

pH SCALE



(Study FIGURE 1.24 in text)

SOIL AIR

- **Dynamic component**
  (in balance with soil water)

- **varies in composition from atmospheric air**
  - **higher in water vapor content than atmos**
    - **may reach 100% relative humidity**
  - **higher CO_2 than atmosphere**
  - **lower O_2 than atmosphere**
    - **(may become anoxic)**

- **not continuous, in many, separated pores**

- **changes rapidly in balance with soil water**

PLANT NUTRIENT SUPPLY

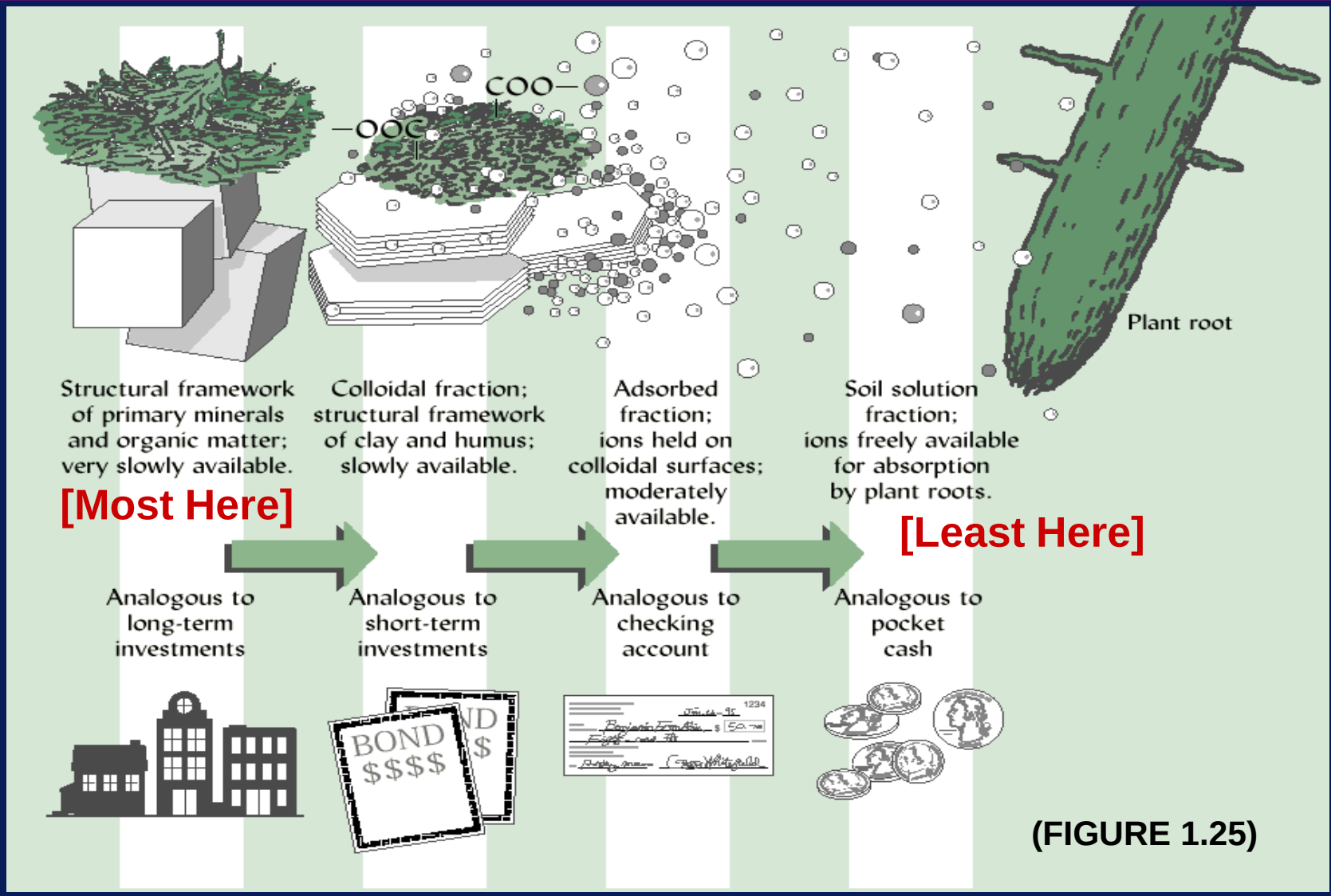
Essential element availability:

- **soil solution concentrations are low**
- **ion exchange important**

$$[\text{colloid}]K^+ + H^+ \rightarrow [\text{colloid}]H^+ + K^+$$

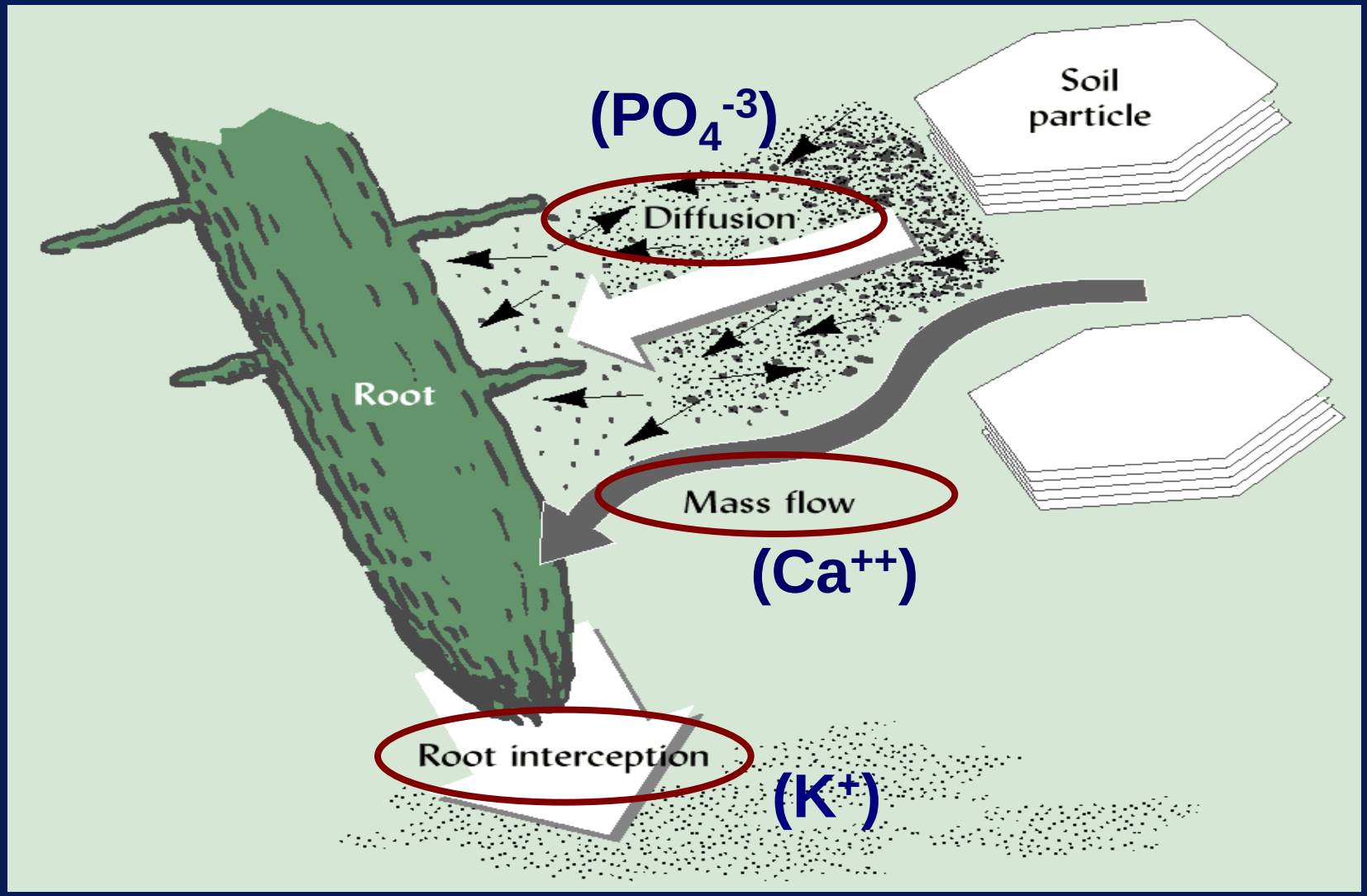
(adsorbed) (soil solution) (sorbed) (soil solution)

SOIL FORMS OF NUTRIENTS



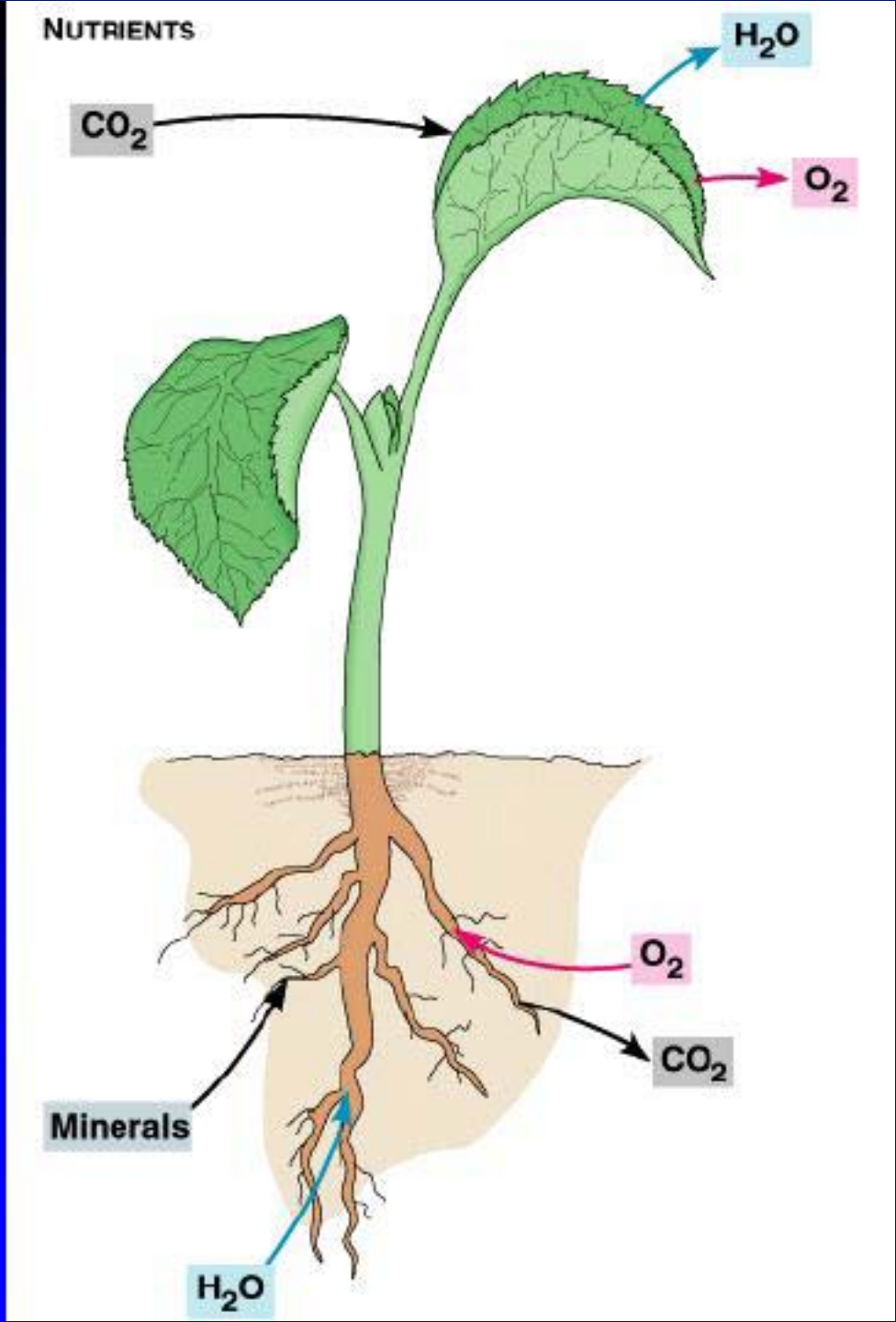
(FIGURE 1.25)

Nutrient elements exist in soils in various forms characterized by different accessibility to plant roots.



Three principal mechanisms by which nutrient ions dissolved in the soil solution come into contact with plant roots. All three mechanisms may operate simultaneously, but one mechanism or another may be most important for a particular nutrient. (FIGURE 1.27)

Uptake of Nutrients by Plants



MINERAL UPTAKE BY PLANTS

- Nutrient ions must be dissolved in soil water ("soil solution") for uptake by plants
- They move from "soil solution" to vascular center of plant root passing through at least one cell membrane (the "skin" that hold the cell's liquid contents inside)
- This movement, across the membrane, may be passive or active

SOIL QUALITY, DEGREDATION & RESILIENCE

Soil quality:

- a measure of a soil's ability to carry out particular ecological functions
- reflection of a combination of chemical, physical and biological properties
- degradation is caused by mismanagement
- resilience is soils ability to recover from minor degradation
- restoration is needed for severely degraded soils (add'n of amendments, other)