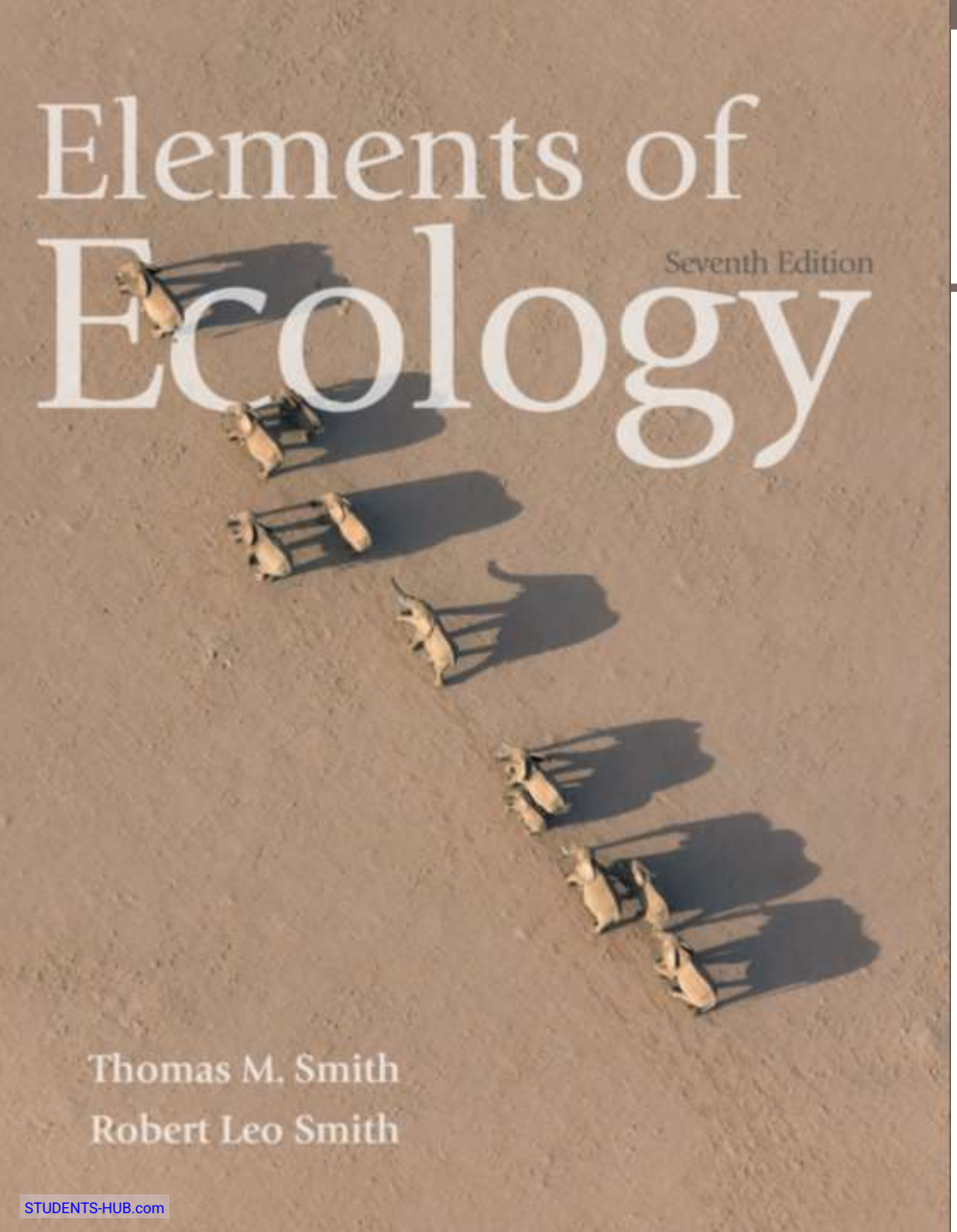


Chapter 4

The Terrestrial Environment

Lecture prepared by
Aimee C. Wyrick

Chapter 4: The Terrestrial Environment

- The **physical** and **chemical features** of terrestrial environments set the **constraints** for life.

4.1 Life on Land Imposes Unique Constraints

- **Constraints include:**

  1) Dessication, or the loss of water, is probably **the greatest constraint** imposed by terrestrial environments.

  - Water evaporates from cell and body surfaces via the process of diffusion.
  - Organisms must **maintain a water balance** and **minimize water lost**.

  – *Waxy cuticle of plants prevent water loss.*

- Any **water lost** from the organism **must be replaced** to maintain water balance:
  - Terrestrial animals **acquire water by drinking and eating**
  - **Vascular tissues transport water** and nutrients throughout the bodies of **terrestrial plants**.

2) **Gravitational forces** are much greater for terrestrial organisms, which have to invest in **structural materials** to **remain erect**:

- Skeletons for animals
- Cellulose for plants

- An aquatic organism would be unable to support its body if brought onto land.

(a)

The **giant kelp**, a marine algae that grows 30 m without supporting tissues.

(b)

Redwood trees of the same height allocates 80% of its total mass to supportive tissue.

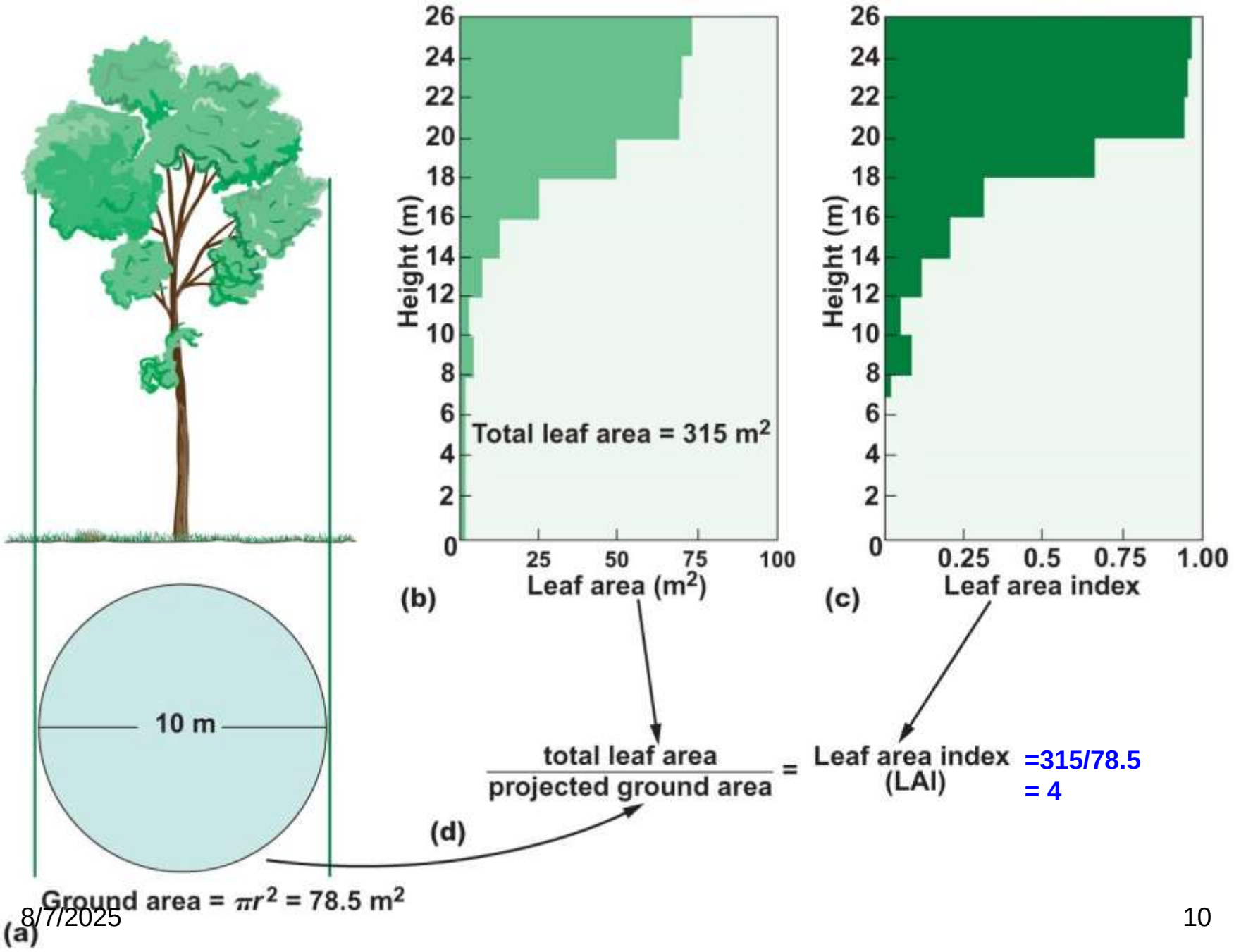
3)Terrestrial environments

experience a high degree of ***variability:***

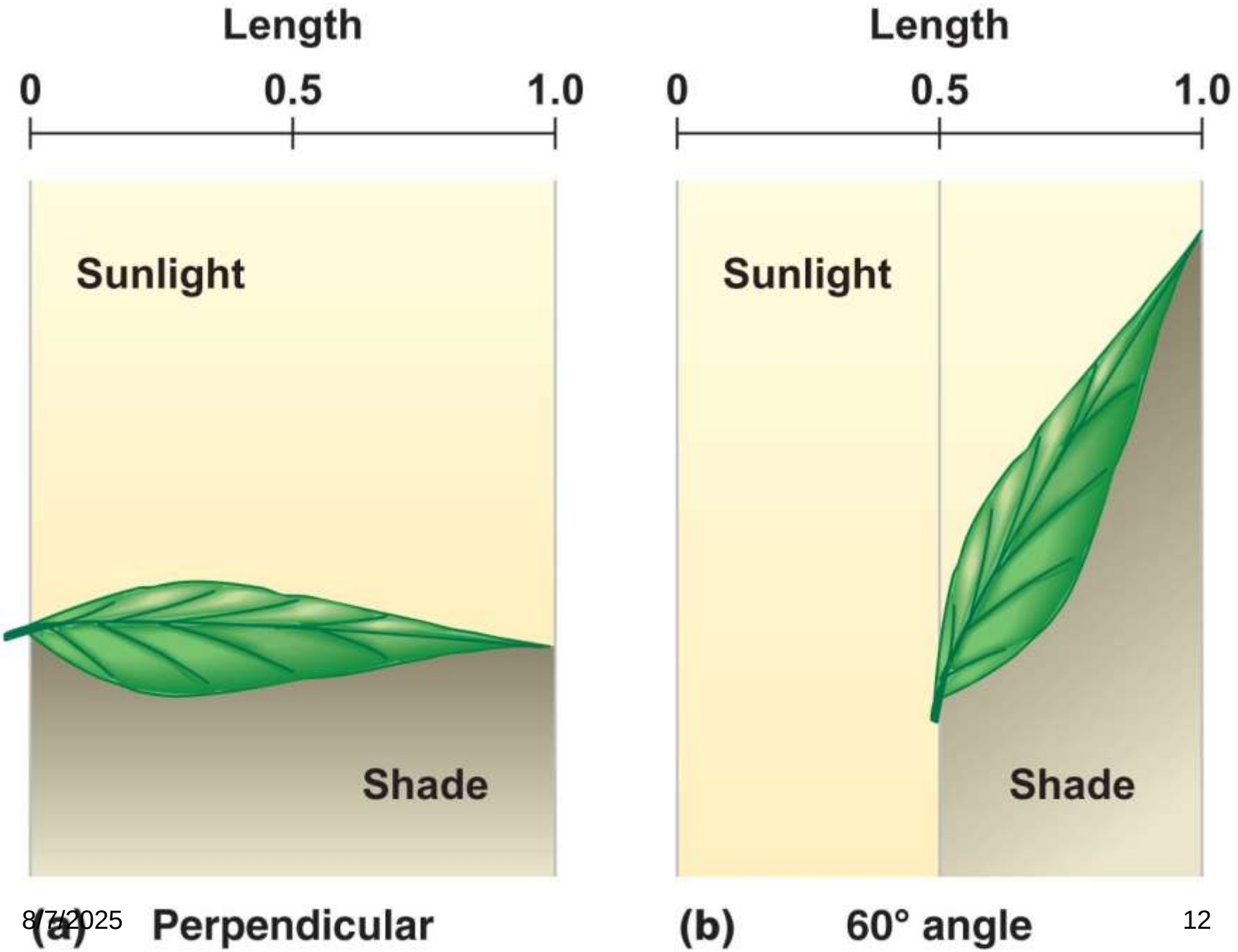
- **Temperature variations** are much greater
- The timing and **quantity of precipitation** constrain the availability of water.

4.2 Plant Cover Influences the Vertical Distribution of Light

- The **vertical gradient and quality of light** in terrestrial environments are determined by the **absorption** and **reflection** of solar radiation by plants.
- **Number, size, and shape of leaves:**
  - **Leaf area** (of flat leaves) = *surface area of one or both sides.*
  - **Leaf area index (LAI)** = *the area of leaves per unit ground area.*
  - [LAI of 3 means: 3m² leaf area over 1m² ground area]
- Cumulative leaf area and LAI increase as you move from the top of the forest canopy to the ground.



- **Orientation of leaves** or angle at which the leaf is held on the plant influences the attenuation of light through the canopy:
  - *A leaf perpendicular to the Sun absorbs 1.0 unit of light energy.*
  - *A leaf displayed at a 60° will absorb 0.5 unit of light energy*



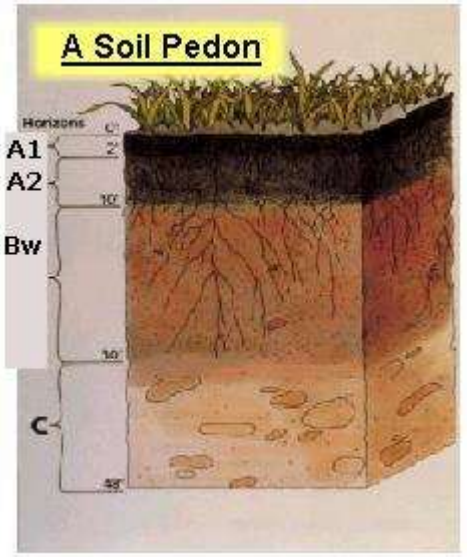
- **Sunflecks** can account for *70 to 80 percent of the solar energy reaching the ground in forest environments.*

- **Seasonal changes strongly influence leaf area:**
  - **Deciduous plants** shed their leaves during the **winter months** (**LAI decreases**).
  - There is increased light availability **during dry conditions** in regions with distinct wet and dry seasons (**LAI decreases**).

4.3 Soil is the Foundation upon Which All Terrestrial Life Depends

- **Soil** is the medium for **plant growth** and **habitat** to a diversity of animal life.
- **Soil is difficult to define:**
  - **One definition says that:** soil is a natural product formed & synthesized by the weathering of rocks and the action of living organisms.
  - **Another definition states that:** soil is a collection of natural bodies of earth, composed of mineral and organic matter and capable of supporting plant growth.

- Soil is a **three-dimensional unit** having length, depth and width.
- Soil is **teeming with life** and includes interactions between biotic and abiotic processes.
- The **regolith** *is the unconsolidated debris overlaying hard, unweathered rocks.*



4.4 The Formation of Soil Begins with Weathering

- **Weathering** *is the destruction of rock materials into smaller particles.* *2 types:*
  - **Mechanical weathering:** results from the action of water, wind, temperature, and organisms (especially plant roots)
  - **Chemical weathering:** occurs when particles are chemically altered (in presence of: water, oxygen, acids) and are further broken down.

4.5 Soil Formation Involves Five Interrelated Factors

1) Parent material is the material from which soil develops:

- Soil properties are primarily determined by the original characteristics of the parent material.

2) Biotic factors contribute to soil formation:

- Plant roots hasten the process of weathering and pump nutrients from the soil depths up to the surface.
- Through photosynthesis, plants return some of the Sun's energy to the soil in the form of organic carbon.
- Through decomposition, dead plants and animals become organic matter incorporated into the soil.

3) The **climate** (temperature, precipitation, winds) affects physical/chemical breakdown of parent material:

- **Leaching** is the movement of solutes through the soil.
- **Temperature** influences the *rates of biochemical reactions.*

4) Topography (contour of the land) affects erosion, deposition and water infiltration into soil.

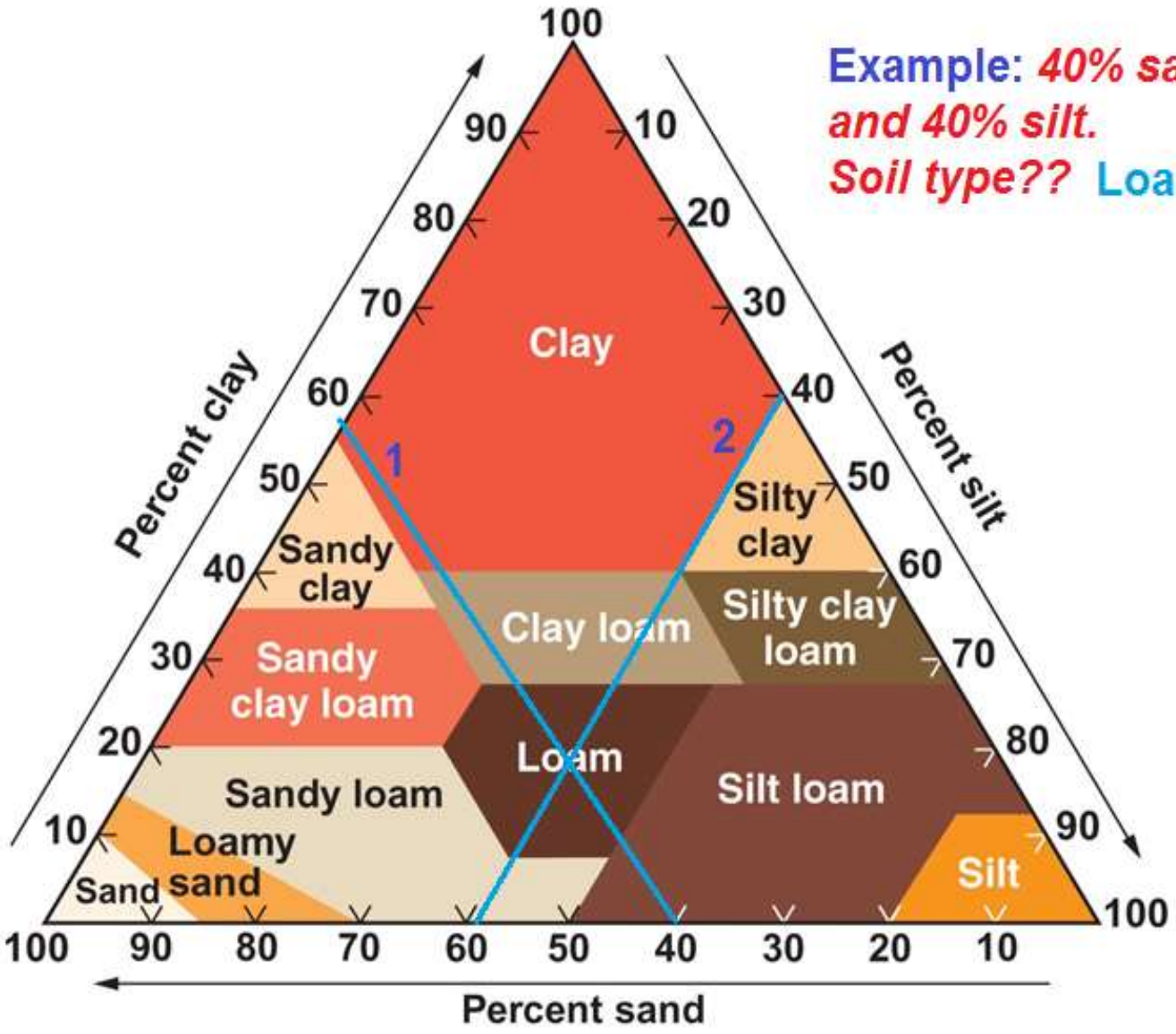
5) Time: Considerable **time** is required for soil to form.

- Well-developed soil may require **2000 to 20,000** years to form!

4.6 Soils Have Certain Distinguishing Physical Characteristics

- **Soil color** is an easily defined and useful characteristic of soil (it has little influence on soil function):
  - **Organic matter** (humus) is **dark or black**
  - **Iron oxides** are **yellowish-brown** to **red**
  - **Manganese oxides** are **purplish** to **black**
  - **Quartz, kaolin, gypsum, and carbonates** are **whitish** and **grayish**

- Soil **texture** *is the proportion of different-sized soil particles:*
  - **Gravel > 2.0 mm in diameter**
  - **Sand = 0.05 to 2.0 mm**
  - **Silt=0.002-0.05 mm**
  - **Clay < 0.002 mm**
- Soil texture affects pore space and the movement of air and water in and through the soil.
- Soil texture is determined using **soil texture triangle:**



Soil texture trianlge

- **Soil depth** varies and depends on many factors:
  - Slope
  - Weathering
  - Parent material
  - Vegetation
- Shallow soils: under forests and on steep slopes.
- Deep soils: under grasslands and bottom of slopes.

4.7 The Soil Body Has Horizontal Layers, or Horizons

- A **soil profile** is a sequence of horizontal layering.
- Soil **horizons** are horizontal layers of soil material

Soil horizons

- A general **soil profile** consists of four horizons:
  1) The **O horizon** is dominated by **organic material**
  2) **The A horizon (topsoil)** is composed of **mineral soil and organic material** leached from above accumulation:
     - The **E horizon** is the zone of maximum leaching (**eluviation**) and is found in the A horizon

3) **The B horizon (subsoil)** **accumulates mineral particles** and contains **less organic matter** than layers above.
   - Minerals leached from above are deposited in a process called **illuviation.**

4) **The C horizon** is the **unconsolidated material that lies under the subsoil.**

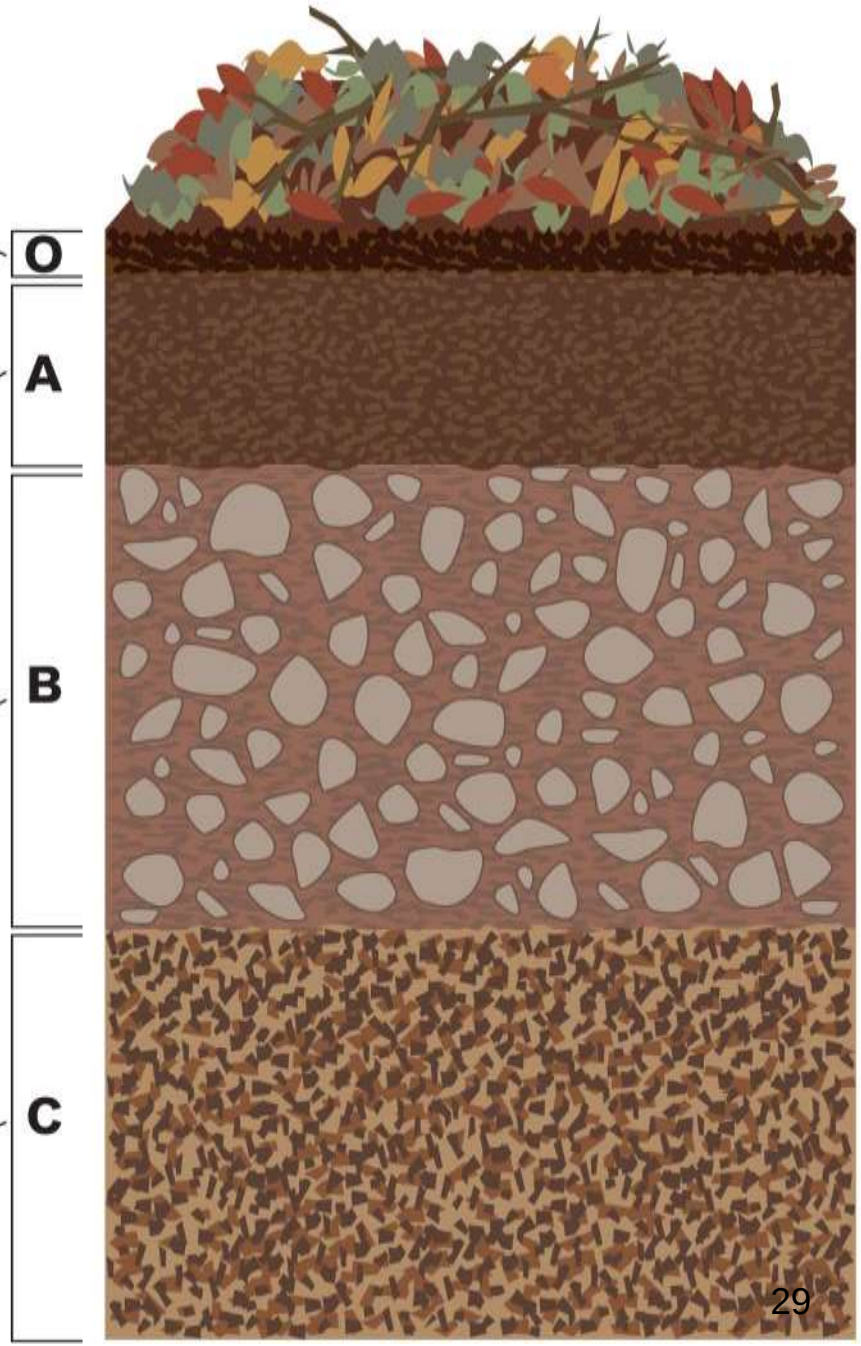
- The bedrock lies below the C horizon.

Organic layer: dominated by organic material, consisting of undecomposed or partially decomposed plant materials, such as dead leaves

Topsoil: largely mineral soil developed from parent material; organic matter leached from above gives this horizon a distinctive dark color

Subsoil: accumulation of mineral particles, such as clay and salts leached from topsoil; distinguished based on color, structure, and kind of material accumulated from leaching

Unconsolidated material derived from the original parent material from which the soil developed

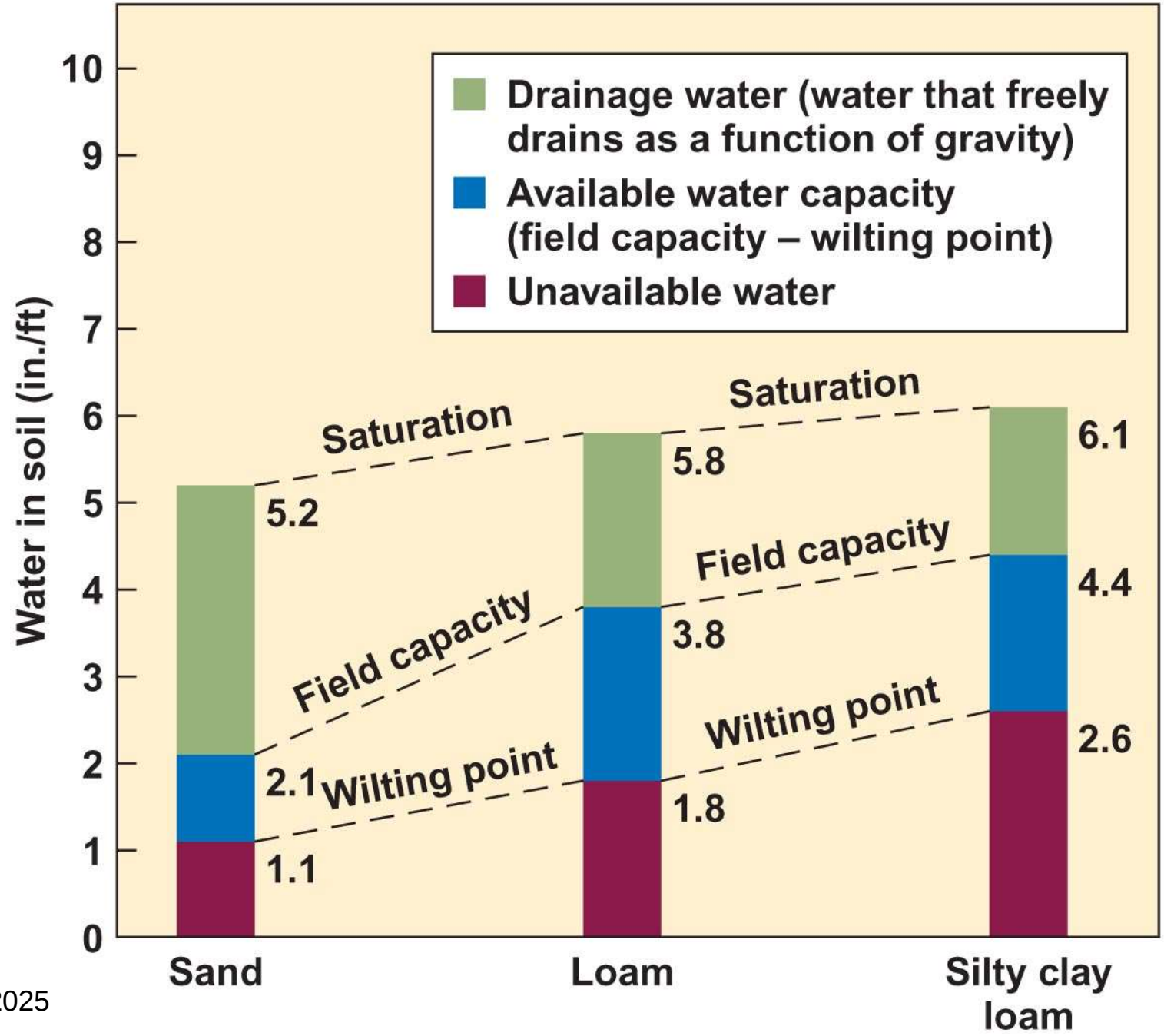


4.8 Moisture-Holding Capacity Is an Essential Feature of Soils

- As rain falls on the surface, it moves into the soil by infiltration.
- The soil is **saturated** when *there is more water than the pore space can hold and excess water drains from the soil*
- The soil is at **field capacity** when *water fills all of the pore spaces and is held by capillary forces*
- Water held between soil particles by capillary forces is **capillary water**

- The **wilting point** is reached *when plants can no longer extract water from the soil.*
- The amount of water retained between **field capacity** (FC) and **wilting point** (WP) is the **available water capacity (AWC)**
  - This is the water available to plants for uptake

- The **field capacity (FC)** and **wilting point (WP)** of soil are influenced by soil texture:
  - **Coarse texture: low FC and low WP**
  - **Fine texture: high FC and high WP**

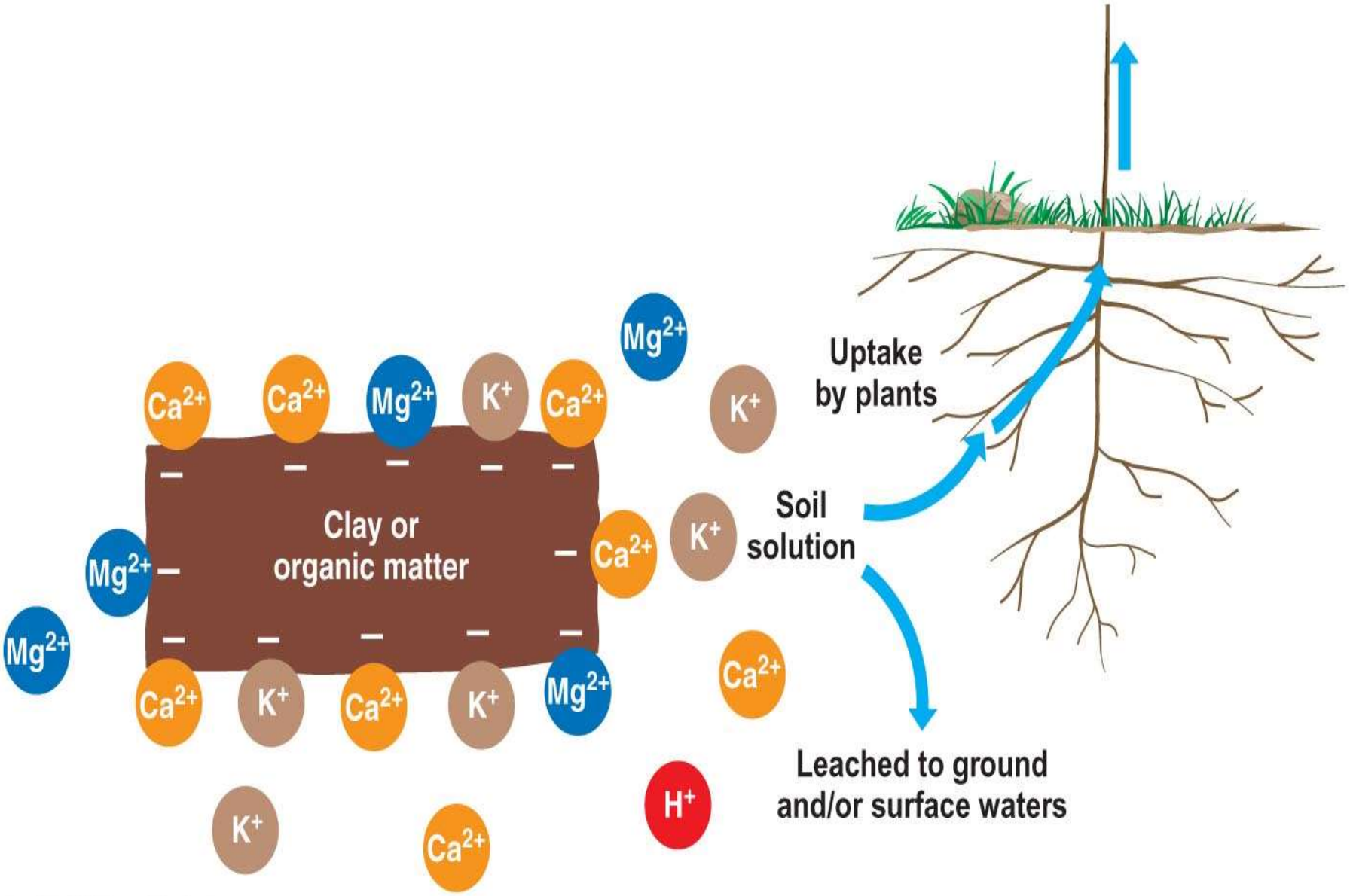


4.9 Ion Exchange Capacity Is Important to Soil Fertility

- Chemicals within the soil dissolve into the soil water to form a solution
- An **ion** is a charged particle
  - A **cation** is a positively charged ion (Ca^{2+}, Mg^{2+}, NH_4^+)
  - An **anion** is a negatively charged ion (NO_3^-, SO_4^{2-})

- The ability of ions to bind to soil particles **depends on** the total number of positively or negatively charged sites (**ion exchange capacity**)
- **Cation exchange** is more prevalent in temperate soils because of negatively charged soil particles (**colloids**):
  - The **cation exchange capacity** (**CEC**) *is the total number of negatively charged sites.*
  - The **CEC** is a basic measure of soil quality.

- Soil-bound cations are in dynamic equilibrium with cations in the soil solution and are continuously being exchanged.
- The **smaller and more positive an ion**, the **more tightly** it is held to the soil particle:
  - $Al^{3+} > H^{+} > Ca^{2+} > Mg^{2+} > K^{+} = NH_4^{+} > Na^{+}$



- As **hydrogen ions (H^+)** are added to a soil, **other cations are displaced** and the soil becomes **increasingly acidic**
- As **soil acidity increases** (pH decreases), the proportion of **aluminum (Al^{3+}) in soil solution increases.**
  - **High [Al^{3+}] in the soil can be toxic to plants and damages the plant roots**.