Ecological Factors

Ecological factors are the environmental factors that affect the survival and growth of organisms in an ecosystem.

Ecological factors shape the diversity and distribution of organisms across different habitats and regions.

These include both **biotic** (living) and **abiotic** (non-living) **factors**.

Biotic Factors

Biotic factors are the living components of the environment, such as plants, animals, fungi, bacteria, and viruses. These interact with each other and with the abiotic factors in various ways, such as predation, competition, symbiosis, decomposition, and nutrient cycling.

Types of interactions between the organism and its biotic factors

The following types of interactions between the biotic factors and the organism are important.

Type of Interaction	Description	Examples
Neutralism	Neither population is affected by association with the other.	Two species living in the same area but not interacting or influencing each other, such as a desert tortoise and a desert bird that do not share resources.
Competition (Direct Interference Type)	Both populations actively inhibit each other.	Deer and elk competing for territory, which can lead to aggressive interactions. Crows and starlings competing for nesting sites, involving physical interference such as removing materials from each other's nests.
Competition (Resource Use Type)	Each population adversely affects the other indirectly in the struggle for resources in short supply.	Various grass species in a grassland competing for water, leading to reduced water availability for each species.
Amensalism	One population is inhibited and the other is not affected.	A large tree shading out smaller plants beneath it, where the smaller plants struggle to survive, but the tree remains unaffected.

Commensalism	One population benefits, but the other is not affected.	Barnacles attaching to a whale; the barnacles benefit from transportation and increased food sources, while the whale is largely unaffected.
Parasitism	One population adversely affects the other by continuous attachment and slow withdrawal of food resources	Tapeworms in humans
Predation	One population adversely affects the other by direct attack for food. In a single encounter, large amounts of biomass get removed. The attacked species may die.	A lion hunting a deer
Protocooperation (Facultative Cooperation)	Both populations benefit by the association but their relations are not obligatory.	Honey bees pollinating flowers; both species benefit, but they can survive independently.
Mutualism	The growth and survival of both populations is benefited, and neither can survive under natural conditions without the other.	Mycorrhizal fungi and plant roots; the fungi enhance nutrient absorption for the plant, while the plant provides carbohydrates necessary for the fungi's survival.

In addition, the **decomposers** are also important biotic factors. They are described as follows.

Decomposers & Decomposition

Decomposition is the natural process of breaking down complex organic matter into simpler inorganic substances such as carbon dioxide, water, and nutrients.

Materials Involved in Decomposition

- **Detritus**: Consists of dead plant material (leaves, bark, flowers) and animal remains, including fecal matter. This forms the raw material for decomposition.

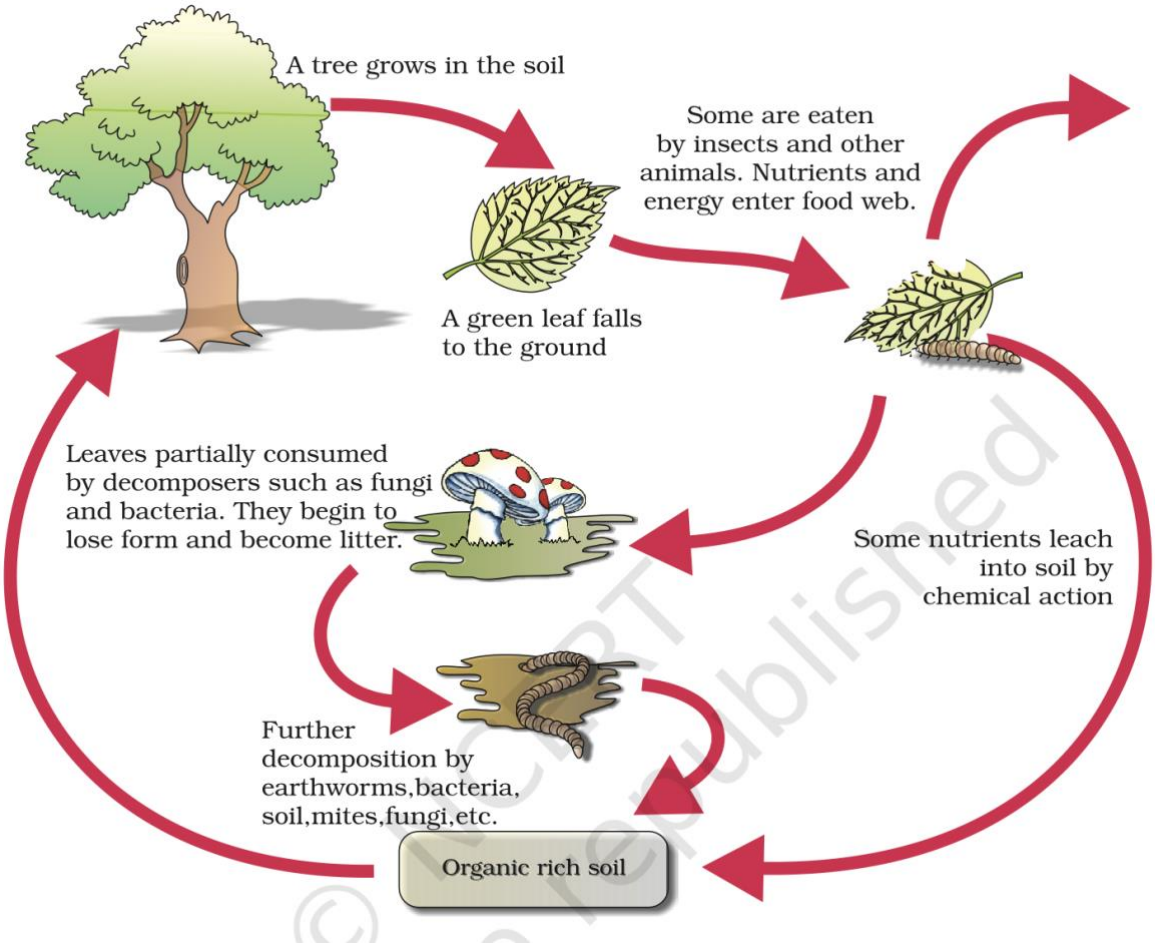
Primary Agents in Decomposition

- **Detritivores**: Organisms, including earthworms, that fragment detritus into smaller pieces, facilitating further microbial action. Often referred to as the farmer's 'friend', earthworms contribute significantly to soil health by breaking down organic matter and aerating the soil.
- **Decomposing microbes**: They include some fungi and bacteria which secrete external enzymes to break down detritus or smaller fragments of detritus and convert that into simpler chemicals.

Processes Involved in Decomposition

Decomposition involves several key steps: **fragmentation**, **leaching**, **catabolism**, **humification**, and **mineralisation**. These processes operate simultaneously on the detritus.

1. **Fragmentation**: Carried out by detritivores, this process involves breaking down detritus into smaller pieces, increasing its surface area for microbes to act upon.
2. **Catabolism**: Bacterial and fungal enzymes degrade detritus into simpler inorganic substances.
3. **Leaching**: The process where water-soluble inorganic nutrients are washed into deeper soil layers, where they precipitate as salts, becoming less available to organisms.
4. **Humification:** Leads to the accumulation of a dark coloured **amorphous substance** called **humus**, which is highly resistant to microbial action and decomposes at an extremely slow rate. Humus, being **colloidal** in nature, serves as a reservoir of nutrients.
5. **Mineralisation:** Humus is further degraded by some microbes, resulting in the release of inorganic nutrients.



Factors Influencing Decomposition

- **Chemical Composition of Detritus**:
    - Rich in lignin and chitin: Slows down decomposition.

    - Rich in nitrogen and water-soluble substances: Accelerates decomposition.
- **Climatic Factors**:
    - **Temperature and Moisture**: Warm and moist conditions are favourable for decomposition, enhancing microbial activity.
    - **Low Temperature and Anaerobic Conditions**: Inhibit decomposition, leading to organic material buildup.

Simultaneity of Decomposition Steps

- All processes in decomposition, including fragmentation, leaching, catabolism, humification, and mineralisation, occur simultaneously and are interdependent, each influencing the overall decomposition rate and efficiency.

Abiotic Factors

Abiotic components are nonliving chemical and physical factors in the environment. Often, these are described as light, temperature, water, atmospheric gases, wind as well as soil (edaphic) and physiographic (nature of land surface) factors. The non-living factors are either **resources** or **conditions**. These relations vary from one organism to another.

Important Abiotic Components are 7 in number:

1. Light
2. Temperature
3. Water
4. Atmospheric gases
5. Wind
6. Soil (edaphic)
7. Physiographic (nature of land surface) factors.

1. Light

Overview of Light Energy in Ecosystems

- **Primary Source**: **Light energy (sunlight)** is crucial as the main energy source in most ecosystems.
- **Utilisation**: Utilised by green plants containing **chlorophyll** for **photosynthesis**, a process where organic substances are synthesised from inorganic ones.
- **Importance of Visible Light**: Essential for photosynthesis, making it critical for plant life.

Factors Influencing Light in Ecosystems

- **Quality of Light (Wavelength or Colour)**:
    - **Absorption**: Plants predominantly absorb **blue and red light** during photosynthesis.
    - **Variation in Ecosystems**:

        - **Terrestrial**: Minimal change in light quality.
        - **Aquatic**: Light quality can be a limiting factor, with blue and red light failing to penetrate deep water. Some algae have evolved additional pigments to absorb other colours.

- **Light Intensity ("Strength" of Light)**:
    - Varies with latitude and season, affecting how much light reaches the Earth. The southern hemisphere experiences less than 12 hours of sunlight from **21st March to 23rd September** and more than 12 hours in the subsequent six months.
- **Day Length (Photoperiodism)**:
    - Influences plant flowering times, as they can "measure" the length of night, reacting to the relative lengths of daylight and darkness—a phenomenon known as **photoperiodism**.

Plant Responses to Light

- **Short-Day Plants**:
    - Flower only when night length exceeds a specific duration. Examples include **Chrysanthemum sp.**, **Euphorbia pulcherrima**, and **Datura stramonium**.
- **Long-Day Plants**:
    - Flower when nights are shorter than a critical length. Examples are **Spinach**, **Wheat**, **Barley**, **Clover**, and **Radish**.
- **Day-Neutral Plants**:
    - Flowering not influenced by night length. Examples include **tomato (Lycopersicon esculeutum)** and **maize (Zea mays)**.

Plant Growth Responses to Light

- **Phototropism**:
    - Directional growth towards light, demonstrating positive phototropism in stems.
- **Phototaxis**:
    - Movement of an organism towards a unilateral light source.
- **Photokinesis**:
    - Variation in locomotory activity based on light intensity, independent of direction.
- **Photonasty**:
    - Movement of plant parts in response to light without direction dependency.

Light Adaptation and Stratification in Plants

- Different light requirements lead to visible layers or **stratification** within ecosystems.
- **Heliophytes** (from Greek 'helios', sun): Thrive in bright sunlight.

- **Sciophytes** (from Greek 'skia', shade): Prosper in shady conditions.

2. Temperature

Influence of Temperature on Distribution:

- Extremes in temperature, such as **warm seasons** and **frost**, critically influence plant and animal distribution.

Temperature Effects on Plants:

- Temperature differences between day and night often trigger the **opening and closing of flowers**.
- **Biennials** like **carrots** germinate in spring or summer through **vernalization**.
- Certain fruit trees, including **peaches**, require a **cold dormancy period** to blossom in spring.
- **Deciduous trees** enter dormancy in winter, protecting buds against the cold.
- Seeds of **peach** and **plum** require **chilling** during cold periods before germination to ensure survival post-winter.

Temperature Effects on Animals:

- Distinction between **ectothermic** (cold-blooded) and **endothermic** (warm-blooded) animals, with varying temperature tolerances.
- Desert animals exhibit distinct activity periods due to drastic day-night temperature variations; for example, nocturnal pollination in **cacti**.
- Seasonal behaviors significantly affect animals:
    - **Torpor** in winter observed in reptiles and some mammals.
    - **Hibernation** during colder months, where animals like **bears** accumulate fat reserves and become dormant.
    - **Aestivation** during warm, dry conditions seen in species like **snails** and the **African lung-fish**.
- **Seasonal migration** observed in species such as **migratory locusts**, **butterflies**, and marine animals like **whales** and **penguins**.

3. Water

Plant and animal habitats vary from entirely aquatic environments to very dry deserts. Water is essential for life and all organisms depend on it to survive in especially desert areas.

Plant Water Requirements

Plants can be classified into three categories based on their water needs:

- **Hydrophytes**:
    - These plants grow in water-rich environments.
    - Examples include water-lilies and rushes.
    - Adapted to abundant water availability and often have features to manage excessive water uptake.

- **Mesophytes**:
    - Require moderate amounts of water.
    - Commonly found in environments where water is sufficiently available but not excessive.
    - Examples include roses and sweet peas.
- **Xerophytes**:
    - Thrive in dry environments where water is scarce.
    - Have adaptations like thick cuticles, reduced leaf sizes, or spines to minimize water loss.
    - Examples include cacti and succulents.

Water Requirements of Animals

Terrestrial animals face the challenge of desiccation and have evolved various adaptations to conserve water:

- **Body Covering**:
    - Helps limit water loss.
    - Includes chitinous exoskeletons in insects, scales in reptiles, feathers in birds, and fur in mammals.
- **Tissue Tolerance to Water Loss**:
    - Some animals, like camels, have tissues that can tolerate dehydration, allowing them to survive without water for extended periods.
- **Atmospheric Water Absorption**:
    - Certain insects can absorb water vapour directly from the environment.
    - An example is the insects of the Namib Desert, which utilise dew from coastal fogs as a crucial moisture source.

4. Atmospheric gases

- **Essential Gases for Life**: Oxygen, Carbon Dioxide, and Nitrogen are crucial for both plant and animal life.
    1. **Oxygen**:
        - Utilised by all living organisms for respiration.
        - Essential for cellular energy production.
    2. **Carbon Dioxide**:
        - Used by green plants in the process of photosynthesis.
        - Helps plants convert light energy into chemical energy, producing oxygen as a by-product.
    3. **Nitrogen**:
        - Vital for plant growth; a major component of chlorophyll and amino acids.

        - Made available to plants primarily by nitrogen-fixing bacteria and the atmospheric effects of lightning.

5. Wind

- **Global Wind Formation**: Arises from complex interactions between expanding and rising hot air, and the Earth's rotational effects.
- **Hot Air Rise**: Predominantly due to convection at the equator and mid-latitudes (0°-30° North and South).
- **Coriolis Force**: Generated by Earth's rotation at mid-latitudes, deflecting winds.
- **Water Vapour Transport**: Winds carry water vapour which can condense and fall as rain, snow, or hail.
- **Ecological Roles of Wind**:
    - Pollination and seed dispersal for certain plants.
    - Dispersal of some animal species, including insects.
- **Wind Erosion**: Can remove and redistribute topsoil, especially in areas with reduced vegetation.
- **Fire Hazard**: Warm winds lead to desiccation, increasing fire risks.
- **Plant Growth Impact**: Plants exposed to strong prevailing winds tend to be smaller than those in less windy conditions.

6. Soil (edaphic factors)

These factors include soil texture, soil air, soil temperature, soil water, soil solution and pH, together with soil organisms and decaying matter.

Soil texture

- **Soil Particle Size**: Ranges from microscopic **clay** to larger **sand** particles.
- **Loam Soil**: Combination of sand and clay.
- Sandy Soils:
    - **Pros**: Well aerated, quick drainage, quick warming, easy to cultivate.
    - **Cons**: Poor water retention, low nutrient content.
- Clay Soils:
    - **Pros**: High water retention, rich in nutrients.
    - **Cons**: Poor aeration, prone to waterlogging, difficult to cultivate, cold in winter.
- Loam Soils:
    - **Advantages**: High water retention, good aeration, rich nutrients, easy cultivation.

Soil air

Soil air is found in those spaces between the soil particles that are not filled with soil water. The amount of air in a soil depends on how firmly the soil is compacted. In well-aerated soil at least 20% of its volume is made up of air.

Soil temperature

Soil temperature is an important ecological factor. It has been found that the temperature of soil below a depth of about 30cm is almost constant during the day but seasonal temperature differences do occur. At low temperature, there is little decay by decay-causing micro-organisms.

Soil water

- **Types of Soil Water**:
    - **Hygroscopic Water**:
        - Occurs as a thin film around each soil particle.
        - Generally not available to plants due to its strong adherence to soil particles.
    - **Capillary Water**:
        - Held in the tiny spaces between soil particles.
        - Main source of water for plant uptake due to its accessibility and retention within the soil matrix.
    - **Gravitational Water**:
        - Drains downward through the soil under the influence of gravity.
        - Excess gravitational water moves beyond the root zone and is typically not used by plants unless captured by deeper soil layers.

Soil solution

The **liquid phase of soil**, consisting of water that contains dissolved gases, minerals, and organic matter.

- **Formation of Soil Solution**:
    - Water absorbs gases and collects soluble materials as it moves through the atmosphere.
    - As it percolates through the soil horizons, it further dissolves minerals and organic compounds.
- **Contribution to Humus**:
    - Soil solution mixes with **animal excretory products and faeces** in the soil.
    - This mixture decomposes to form **humus**, a rich organic component that enhances soil fertility by improving nutrient content and soil structure.

6. pH

- **Soil pH Influence**:
    - **Biological Activity**: pH level impacts the microbial and enzymatic activities within the soil.
    - **Mineral Availability**: Certain minerals become more available or restricted based on the soil's pH.

- **Plant Growth and Development**:
    - The pH of the soil is a critical factor influencing plant health and viability.
- **Examples of pH Preferences in Plants**:
    - **Acidic Soils** (pH below 7):
        - Preferred by plants such as Azaleas, Ericas, ferns, and many Protea species.
    - **Alkaline Soils** (pH above 7):
        - Favourable for plants like Lucerne and many xerophytes.

7. Physiographic factors

These factors are those associated with the physical nature of the area, such as altitude, slope of land and the position of the area in relation to the sun or rain-bearing winds. **Altitude** plays a role in vegetations zones. **Slopes** are important when considering the temperature.