Course: PLANTS

AND

ENVIRONMENT

Course Information

Institute : Natural and Life Sciences

Department : Biotechnology

Target Audience : 2nd-year Bachelor's students

Specialization : Food Sciences

Course Title : Plants and Environment

Credits: 02, **Coefficient**: 02

Schedule : 1 hour 30 minutes per week

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Program

INTRODUCTION: Contexts of the Algerian University

Chapter I: Biocenosis

Chapter Objectives

At the end of this chapter, the student will be able to: Define biocenosis and understand its role in an ecosystem. Identify the main characteristics of biocenoses. Differentiate the types of biocenoses according to various criteria.

- **1. Introduction** The study of the relationships between plants and their environment relies on understanding ecosystems, which are composed of two major elements: The biotope: the set of physicochemical conditions of an environment. The biocenosis: the community of living beings (plants, animals, microorganisms) that interact within this environment. Biocenosis plays a fundamental role in ecological balance by regulating the flow of energy and nutrients through the different trophic levels (producers, consumers, decomposers).

-2. **Notions of Biocenosis** Definition of Biocenosis Biocenosis refers to the set of living organisms coexisting in the same environment and interacting with each other and their surroundings. This concept was introduced by Karl Möbius in 1877 to describe biological

communities present in a given habitat. An ecosystem is therefore composed of: A biotope, which represents the physical environment. A biocenosis, which includes living beings and their interactions.

-**2.1. Characteristics of Biocenoses** Biocenoses are defined by several characteristics:

1. Specific Composition The diversity of species within a biocenosis is essential for its functioning. It includes: Species richness: the total number of species present. Relative abundance: the proportion of each species compared to others.

2. Trophic Organization Biocenoses are structured into food chains and trophic networks: Primary producers (plants, algae): convert solar energy into organic matter. Consumers (herbivores, carnivores, omnivores): feed on other organisms. Decomposers (bacteria, fungi): recycle organic matter into nutrients usable by plants.

3. Interactions Between Species Organisms within a biocenosis interact through several types of ecological relationships: Competition: two species use the same limited resource (e.g., competition for light among plants). Predation: one species consumes another (e.g., phytophagous insects). Mutualism: a beneficial relationship for both partners (e.g., mycorrhizae in plants). Parasitism: one organism lives at the expense of another (e.g., parasitic fungi on plants).

4. Dynamics and Evolution of Biocenoses Biocenoses are not static; they evolve through processes such as: Ecological succession: the gradual replacement of species within an ecosystem (e.g., recolonization of land after a fire). Ecological resilience: the ability of a biocenosis to recover after a disturbance (e.g., forest regeneration after a storm).

- **2.2. Types of Biocenoses** Biocenoses can be classified according to several criteria:

1. Based on the Living Environment Terrestrial biocenosis: includes organisms living on land (forests, savannas, deserts). Aquatic biocenosis: includes communities living in aquatic environments (oceans, rivers, lakes).

2. Based on Biodiversity and Stability Stable biocenosis (climax): an ecosystem that has reached maturity with a stable ecological balance (e.g., ancient tropical forests). Unstable biocenosis (pioneer community): a community in formation, often after a disturbance (e.g., vegetation on a newly forming sand dune).

3. Based on Human Intervention Natural biocenosis: develops without human intervention (e.g., primary forests). Anthropized biocenosis: modified by human activities (e.g., agricultural fields, urban parks).

- **The Main Terrestrial Biomes**

1. **Tundra**

The tundra is a cold biome mainly found in Arctic and sub-Arctic regions. It is characterized by:

- Very low annual average temperatures (barely above 0°C in summer).
- Deeply frozen soil (permafrost).
- Low-growing vegetation consisting of mosses, lichens, grasses, and small shrubs.
- Relatively low biodiversity, but well adapted to extreme conditions.
- A short growing season (2-3 months).

2. **Boreal Forest (or Taiga)**

The boreal forest is located south of the tundra in northern areas of the Northern Hemisphere:

- Cold temperatures with long, snowy winters.
- Dominated by conifers (pines, spruces, firs, larches).
- Acidic and nutrient-poor soils.
- Fauna adapted to cold conditions: moose, brown bears, lynx, wolves.

3. **Temperate Deciduous Forest**

This biome is found in temperate zones with four well-defined seasons:

- Moderate temperatures with regular precipitation.
- Deciduous trees: oaks, beeches, maples.
- Rich and fertile soils.
- High animal and plant biodiversity.

4. **Mediterranean Ecosystems**

Found in Mediterranean regions and also in California, Chile, South Africa, and Australia:

- Hot, dry summers and mild, wet winters.
- Vegetation adapted to drought (maquis, garrigue).
- Predominance of sclerophyllous species (thick and tough leaves).
- Rich and endemic biodiversity.

5. **Temperate Steppe (American Prairie)**

Characterized by:

- Low precipitation (250 to 500 mm per year).

- Grass-dominated vegetation.
- Very fertile soils (chernozems).
- Used for intensive agriculture and livestock.
- Fauna: bison, antelopes, rodents.

6. **Deserts**

Extremely arid biomes characterized by:

- Very low precipitation (< 250 mm per year).
- Extreme temperatures (hot during the day, cold at night).
- Sparse vegetation (cacti, succulents).
- Adapted fauna: reptiles, nocturnal rodents, insects.

7. **Tropical Savanna**

A transition biome between tropical forest and desert:

- Moderate rainfall with a prolonged dry season.
- Vegetation: tall grasses, scattered trees (acacias, baobabs).
- Highly diverse fauna: elephants, giraffes, lions, antelopes.
- Human activities: agriculture, extensive livestock farming.

8. **Equatorial Rainforest**

Located around the equator (Amazon, Congo Basin, Southeast Asia):

- Constant temperatures (±27°C) and very high rainfall (>2000 mm/year).
- Forest stratification (canopy, understory, forest floor).
- Lush vegetation with evergreen foliage.
- Exceptional biodiversity (birds, insects, mammals, plants).

Conclusion

Terrestrial biomes present a wide variety of adaptations to climatic and ecological conditions. Understanding them is essential for biodiversity conservation and sustainable natural resource management.

- **I.2 – Ecosystems: Classification and Characteristics**

1. Terrestrial Ecosystems Associated with Emerged Continents

Terrestrial ecosystems develop on continental surfaces and are influenced by climatic, geological, and biological factors.

Characteristics:

- Tropical Forests: Extreme biodiversity, high temperature, and humidity (e.g., Amazon Rainforest).

- Deserts: Low precipitation, vegetation adapted to drought (e.g., Sahara Desert).

- Grasslands and Savannas: Dominated by grasses, marked dry and wet seasons (e.g., Serengeti).

- Tundra: Polar climate, frozen soil (permafrost), low vegetation (e.g., Siberia).

- Mountains: Altitudinal zonation with variations in temperature and pressure (e.g., Alps).

Key Components:

- Biotic: Plants, animals, microorganisms.

- Abiotic: Soil, temperature, light, precipitation.

2. Aquatic Ecosystems

Aquatic ecosystems include freshwater and marine environments, structured by depth, salinity, and currents.

Types:

- **Freshwater:**

  - Lentic(still waters: lakes, ponds).

  - Lotic (flowing waters: rivers, streams).

- **Marine:**

  - Coastal Zones(mangroves, coral reefs).

  - Pelagic (open waters, plankton).

  - Abyssal (dark depths, bioluminescent organisms).

Biological Adaptations:

- Organisms with gill respiration (fish).

- Floating plants (water lilies) or fixed plants (algae).

3. Microecosystems

Small-scale ecosystems where biotic and abiotic interactions are localized.

Examples:

- A puddle of water: Insect larvae, algae, bacteria.

- A dead tree trunk: Fungi, beetles, worms.

- The gut microbiome: Bacteria, archaea, yeasts.

Importance:

- Maintenance of biodiversity on a small scale.

- Natural laboratories for studying ecological interactions.

4. Mesoecosystems

Intermediate-scale ecosystems often corresponding to specific landscapes or habitats.

Examples:

- A temperate forest: Trophic networks including herbivores, carnivores, and decomposers.

- A lake: Littoral zones, pelagic zones, and deep zones with distinct communities.

- An agricultural field: Interactions between crops, pollinators, and pests.

Functions:

- Regulation of biogeochemical cycles (C, N, P).

- Support for ecosystem services (pollination, water purification).

5. Macroecosystems

Large-scale ecosystems at the planetary or regional level encompassing entire biomes.

Examples:

- Biosphere: Interaction between all Earth's ecosystems.

- Biomes:

  - Boreal Forest(taiga).

  - Indian Ocean (tropical marine ecosystems).

  - Great Grasslands (steppes).

Challenges:

- Climate change and melting polar ice caps.

- Deforestation and biodiversity loss.

Synthesis and Interactions

- Ecological Hierarchy: Microecosystems integrate into mesoecosystems and then into macroecosystems.

- Resilience: Disturbances (fires, pollution) affect each scale differently.

- Conservation:Protecting ecological corridors to maintain connectivity between ecosystems.

Applications:

- Sustainable resource management (fishing, agriculture).

- Ecological restoration (species reintroduction, reforestation).

I.3 Plant Responses to Environmental Factors

1. General Response Mechanisms

Plants, as sessile (fixed) organisms, cannot escape unfavorable environmental conditions. Therefore, they have developed physiological, morphological, and behavioral adaptation mechanisms to respond to various environmental factors, including:

1. Adaptation

➢ **Definition:**

Adaptation is a stable and hereditary genetic modification of a plant species that enables it to survive in a given environment. It results from natural selection over long periods of time.

➢ **Characteristics:**

- **Hereditary:** Passed on to future generations.
- **Long-term:** Part of the evolutionary process.
- **Leads to** the emergence of ecotypes or specialized species.

➢ **Examples:**

- Desert cacti have developed thick stems to store water and spines instead of leaves to reduce evaporation.
- Alpine plants have rosette-shaped, often hairy leaves to conserve heat and protect against wind.

2. Acclimation

➢ **Definition:**

Acclimation is a reversible and non-hereditary physiological response to an environmental change. It allows the plant to quickly adjust to a change, but it is not passed on to offspring.

➢ **Characteristics:**

- **Short to medium term** (from days to seasons).
- **Depends on** the adaptive potential of the species.
- **Helps maintain** optimal physiological function.

➢ **Examples:**

- A plant exposed to more light may produce more photosynthetic pigments (chlorophyll, carotenoids).
- During temporary drought, some plants close their stomata to reduce water loss (a reversible mechanism).

3. Avoidance

➢ **Definition:**

Avoidance is a set of strategies that allow a plant to reduce or bypass exposure to stress without directly resisting it.

➢ **Types:**

- **Morphological avoidance:** Structural changes.
- **Phenological avoidance:** Adjustment of the life cycle.

➢ **Examples:**

- Closing stomata during the hottest hours of the day (to avoid excessive transpiration).
- Desert annuals: rapid germination and short life cycle limited to the rainy season (avoiding summer drought).
- Vertically oriented leaves to avoid maximum sun exposure.

4. Tolerance

➢ **Definition:**

Tolerance is the plant's ability to maintain vital functions even under intense or prolonged stress.

➢ **Characteristics:**

- Based on complex internal mechanisms.
- Can be **physiological** (production of protective molecules) or **biochemical**.

➢ **Examples:**

- Production of heat shock proteins (HSPs) that protect enzymes at high temperatures.
- Synthesis of osmoprotectant compounds (proline, sugars) during water or salt stress.
- Accumulation of antioxidant pigments (flavonoids, anthocyanins) to neutralize free radicals during light or oxidative stress.

 Visual Summary of Mechanism | Duration | Nature | Typical Example

Mechanism	Duration	Nature	Typical Example
Adaptation	Long-term	Genetic	Cactus spines
Acclimation	Short-term	Physiological	Stomatal opening
Avoidance	Variable	Morphological or phenological	Short life cycle in annuals
Tolerance	Short or long-term	Biochemical / Cellular	Antioxidant synthesis

3. Response to Resource Availability

Plants depend on abiotic resources: light, water, CO_2, and soil nutrients.

a. Light:

- **Phototropism:** Orientation toward light.
- **Photoperiodism:** Response to day/night ratio (triggers flowering or dormancy).
- **Leaf acclimation:** Adaptation to light intensity (shade vs. sun leaves).

b. Water:

- **Water-saving mechanisms:** Reduced leaves, thick cuticles, sunken stomata.
- **Plant types:** Xerophytes, mesophytes, and hydrophytes depending on humidity levels.

c. Nutrients:

- **Adapted root systems:** Deep roots, mycorrhizae.

- **Growth reduction in case of deficiencies.**

4. Plant Distribution

The distribution of plant species depends on:

- **Climatic conditions:** Temperature, rainfall, sunlight.
- **Soil characteristics:** pH, texture, nutrient content.
- **Human activities:** Agriculture, deforestation, urbanization.

This distribution creates **biogeographical zones** and **biomes** where only specifically adapted species can survive.

I.4 Functioning of Plant Communities

1. Spatio-temporal Variations in Plant Communities

Plant communities evolve over time (ecological succession) and across space (zonation, gradients).

a. Ecological Succession:

- **Primary:** On virgin substrates (lava, dunes).
- **Secondary:** After disturbances (fire, abandoned farmland).
- **Leads to climax communities:** Stable ecosystems.

b. Spatial Variability:

- Depends on microclimates, topography, soil moisture.
- Zonation in mountains, forests, wetlands, etc.

2. Functioning of Communities and Biogeochemical Cycles

Plant communities play a key role in major natural cycles:

a. Carbon Cycle:

- Photosynthesis → CO_2 storage → Primary productivity.
- Crucial role in climate regulation.

b. Nitrogen Cycle:

- Nitrogen fixation by legumes.

- Nitrate absorption by plants, return through decomposition.

c. Water Cycle:

- Transpiration and evapotranspiration.
- Important for regulating soil and atmospheric moisture.

3. Human Impact on Vegetative Cover Functioning

Human activities drastically alter plant ecosystems:

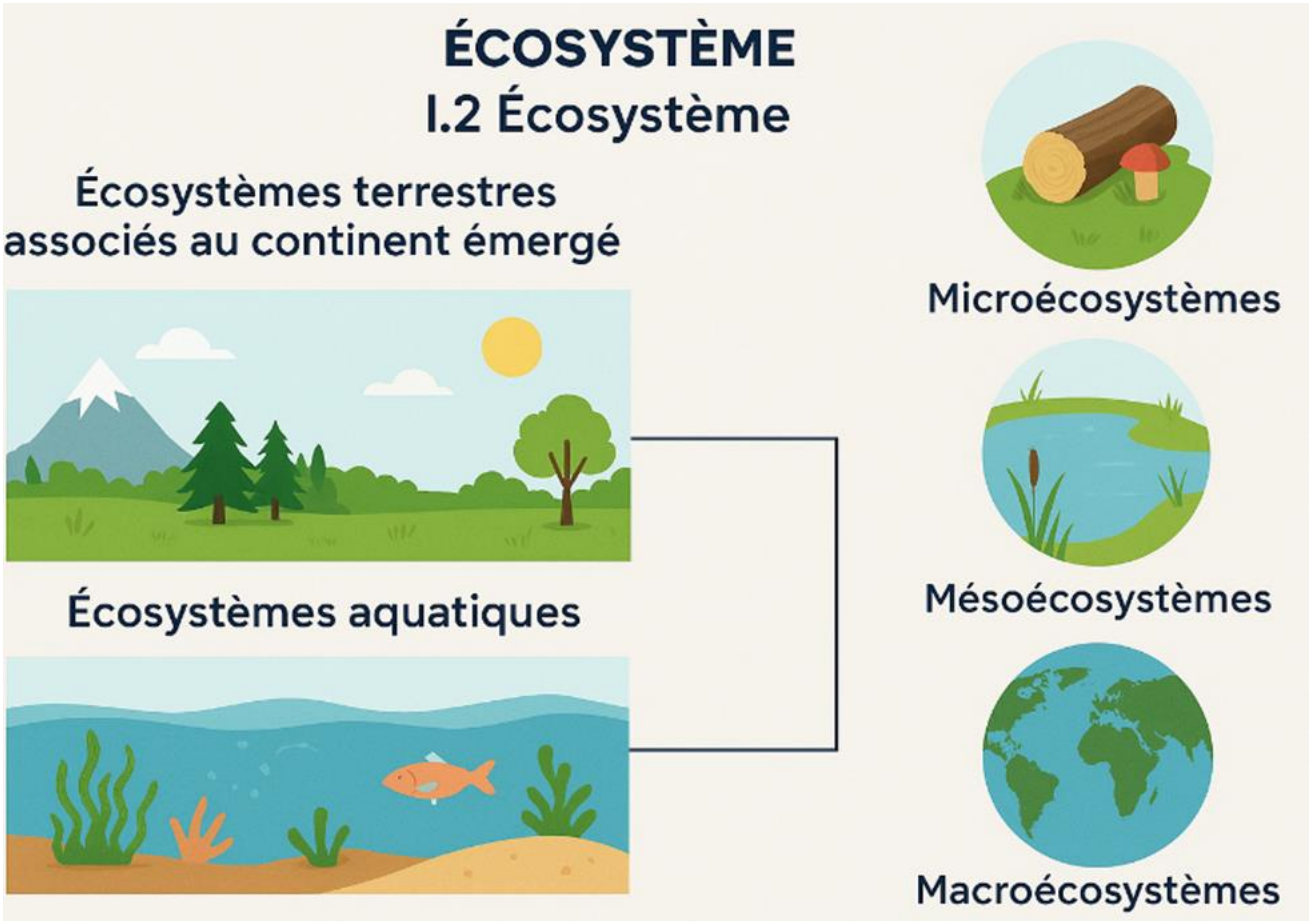
- **Deforestation:** Loss of biodiversity, changes in local climate.
- **Intensive agriculture:** Soil depletion, pollution from fertilizers.
- **Urbanization:** Fragmentation of natural habitats.
- **Climate change:** Shift in species distribution ranges, water stress.

Consequences:

- Decline in ecosystem services (carbon storage, water filtration).
- Loss of ecological resilience.
- Need for sustainable management and ecological restoration.

✓ Conclusion

Studying how plants respond to environmental factors helps us understand their distribution, adaptation, and vulnerability to change. The functioning of plant communities is closely tied to natural cycles, biodiversity, and ecological balance. Understanding these interactions is essential for ecosystem conservation and sustainable development.



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TD1

1: Study the main terrestrial biomes (tundra, taiga, desert, steppes, Mediterranean ecosystems).

2. Identify their climatic, geographical, and vegetative characteristics.

Study of the main terrestrial biomes:

Tundra

- **Climatic characteristics:** Cold, long and dark winters, short and cool summers.
- **Geographical characteristics:** Marshy areas, lakes, and low-fertility soils.
- **Vegetative characteristics:** Low and sparse vegetation, dominated by mosses, lichens, and small shrubs such as willows and birches.

Taiga

- **Climatic characteristics:** Cold, long winters, short and cool summers.
- **Geographical characteristics:** Boreal forests, acidic soils.
- **Vegetative characteristics:** Dominated by coniferous trees such as pines and spruces.

Desert

- **Climatic characteristics:** Arid, hot, with low precipitation.
- **Geographical characteristics:** Sandy and rocky landscapes, absence of dense vegetation.
- **Vegetative characteristics:** Xerophytic plants adapted to drought, such as cacti.

Steppes

- **Climatic characteristics:** Temperate, cold winters, hot summers.
- **Geographical characteristics:** Vast grasslands, fertile soils.
- **Vegetative characteristics:** Dominated by herbaceous plants such as grasses and wild cereals.

Mediterranean Ecosystems

- **Climatic characteristics:** Hot summers, mild winters, summer drought.
- **Geographical characteristics:** Coastal regions, mountainous areas.
- **Vegetative characteristics:** Sclerophyllous forests with trees such as holm oaks and Aleppo pines.

TD 2 reponses

✅ Exercise 1: Multiple Choice Review

The tundra is characterized by:
✅ **Permafrost**
✅ **Low-growing vegetation**
❌ Tropical biodiversity
❌ Heavy rainfall

Lentic ecosystems correspond to:
✅ **Lakes and ponds**
❌ Rivers and streams
❌ Coastal areas
❌ Abyssal zones

An example of a microecosystem is:
✅ **A puddle of water**
❌ The Amazon rainforest
❌ An alpine meadow
❌ A mangrove

Which of the following is an abiotic factor?
✅ **Temperature**
✅ **Precipitation**
❌ Fungus
❌ Insect

An example of plant adaptation in desert environments is:
✅ **Leaves modified into spines**
✅ **A thick cuticle**
❌ Very short roots
❌ Dense foliage

□ Exercise 2: Match each ecosystem with its main characteristic

Ecosystem	Main Characteristic
1. Tropical forest	**C. Broadleaf trees, constant humidity**
2. Steppe	**B. Dominated by grasses, moderate precipitation**
3. Abyssal ecosystem	**A. Extreme environment, great depth, luminous organisms**
4. Stream (lotic ecosystem)	**D. Flowing water, rich in oxygen**
5. Intestinal microecosystem	**E. Symbiotic microorganisms inside a human host**

□ Exercise 3: Complete the Table

Ecosystem Type	Example	Typical Biological Adaptations
Terrestrial	□ Desert	Xerophytic plants with thick cuticles, deep or widespread roots, and animals with nocturnal habits
Aquatic (lentic)	□ Pond	Floating leaves in plants (e.g., water lilies), gills in fish,

		and slow swimming behaviors
Aquatic (lotic)	□ Stream	Streamlined bodies in fish, strong root systems in aquatic plants to resist current
Microecosystem	□ Puddle of water	Rapid life cycles in microorganisms, resistance to evaporation or desiccation
Mesoecosystem	□ Forest clearing	Shade tolerance in understory plants, territorial behavior in small mammals
Macroecosystem	□ Amazon rainforest	Biodiversity, stratified vegetation layers, epiphytic plants, and arboreal animal adaptations