Lecture: 02

Enviornment

Topics Covered:

Ecosystem Basics

- Ecosystem Definitions
- The Structure/Components of Ecosystem
  - Biotic Components
  - Abiotic Components
- Functions and Properties of Ecosystem

Ecosystem Dynamics

- Flow of Energy in Ecosystem
- Trophic Levels
- Food Chain
- Types & Significance of Food Chain
- Food Web
- Models for Energy Flow
- Ecological Productivity
- Ecological Pyramid

Biomagnifications

Biological Control

Organic Farming

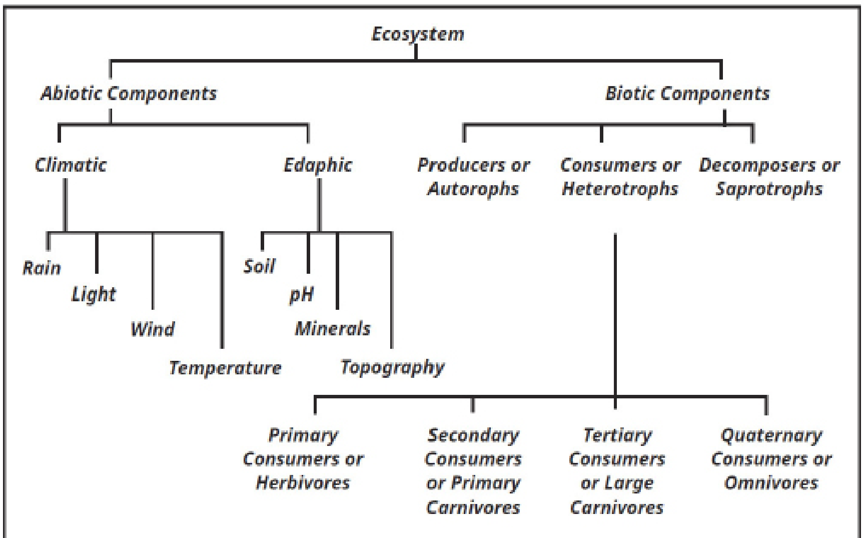
ECOSYSTEM

An **ecosystem** can be visualised as a functional unit of nature, where **living organisms** (producers, consumers, and decomposers) interact among themselves and also with the surrounding **physical environment**.

- An ecosystem is a **structural and functional unit of ecology** where living organisms interact with each other and the surrounding environment.
- An ecosystem can be of any size but usually encompasses specific and limited species. E.g. **Aquatic Ecosystem**. (This is how ecosystem is different from **Environment**)
- In the ecosystem, **biotic** and **abiotic** components are linked together through **nutrient cycles** and **energy flows**.
- Everything that lives in an ecosystem is dependent on the other species and elements that are also part of that **ecological community**.
- If one part of an ecosystem is damaged or disappears, it has an impact on everything else. **Aquatic Ecosystem**.
- The term "ecosystem" was first coined by **A.G. Tansley,** an English botanist, in 1935.

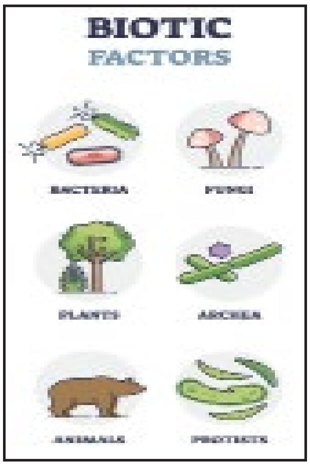
Structure of an Ecosystem

- Ecosystems consist of both living (**biotic**) and non-living (**abiotic**) components.
- Biotic components include **plants**, **animals**, and **microbes**, which are classified into primary producers (**autotrophs**) that create their own food through photosynthesis, and consumers (**heterotrophs**) that depend on organic food from other sources.
- Primary producers, such as **green plants** and **algae**, synthesize carbohydrates using **sunlight** and supply indirectly to other non-producers.



Schematic Representation of the Structure of an Ecosystem.

- Consumers, like **herbivores**, **carnivores**, and **omnivores**, cannot produce their own food and rely on plants or other animals for nutrition.
- Micro consumers, represented by **bacteria** and **fungi**, play a vital role in decomposing dead organic substances, recycling inorganic nutrients, and supporting the ecosystem's overall balance.



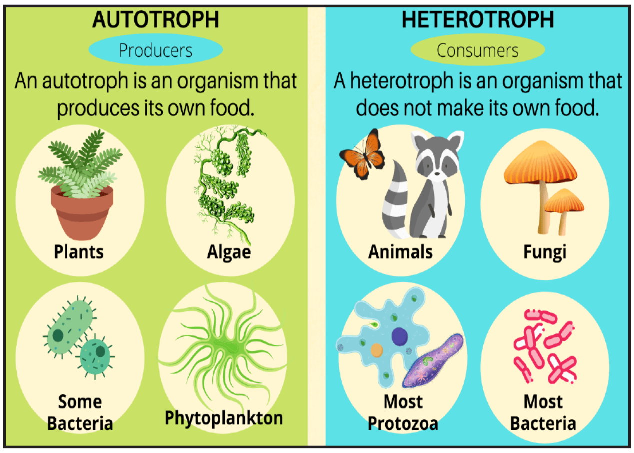
Biotic Components in Ecosystems

1. Primary Producers (Autotrophs)

- **Green plants,** certain **bacteria**, and **algae** are primary producers.
- They carry out **photosynthesis** to create their own food from simple inorganic raw materials like **carbon dioxide** and **water**, with the help of **sunlight**.
- Example: In **aquatic ecosystems, microscopic algae** (plankton) are the primary producers.

2. Consumers (Heterotrophs or Phagotrophs)

- Consumers cannot produce their own food and rely on **organic food** derived from **plants**, **animals**, or both.
- They can be divided into two groups: **micro** and **macro consumers**.



Macro Consumers

- **Herbivores**: Primary consumers that mainly feed on **plants**. Example: **Sheep**, **rabbits**.
- **Secondary Consumers**: Feed on primary consumers. Example:

Wolves, **dogs**, **snakes**.

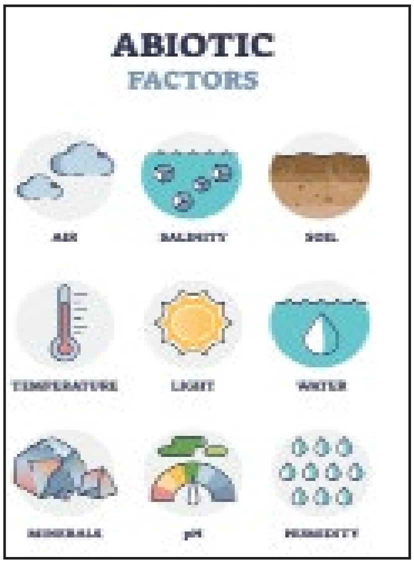
- **Carnivores**: Feed on both primary and secondary consumers. Example: **Lions** (can eat wolves), **snakes**.
- **Omnivores**: Organisms that consume both **plants** and **animals**. Example: **Humans**, **bears**, **pigs**.

Micro Consumers (Saprotrophs or Decomposers)

- **Bacteria** and **fungi** are micro consumers.
- They obtain energy and nutrients by **decomposing dead organic substances** (detritus) from plant and animal origin.
- Saprophytes, such as **fungi and bacteria**, that break down dead and decaying organic matter, recycling nutrients for reuse by plants
- **Earthworms** and certain soil organisms, like **nematodes** and **arthropods**, are detritus feeders and help decompose organic matter. They are called **detrivores**.

Abiotic Components

Abiotic factors are nonliving components of an ecosystem that influence and s hape the environment. These factors play a crucial role in determining the distribution and abundance of living organisms within the ecosystem.



- In terrestrial ecosystems, **abiotic components** include:
  - **Temperature**: The measure of heat energy present in the environment. Different organisms have specific temperature ranges in which they can thrive. Extreme temperatures can be limiting factors for certain species.
  - **Light**: The intensity and spectral quality of sunlight affect photosynthesis and the behavior of organisms. Different plants and animals have adapted to specific light conditions.
  - **Water**: Availability of water is essential for the survival of living organisms. Plants, in particular, are highly dependent on water for various physiological processes.
- In marine ecosystems, in addition to temperature, light, and water, other important **abiotic components** are:
  - **Salinity**: The concentration of salt in water. Organisms living in marine environments have varying degrees of tolerance to salinity levels.
  - **Ocean Currents**: Movements of water in the ocean that influence nutrient distribution and affect marine life.

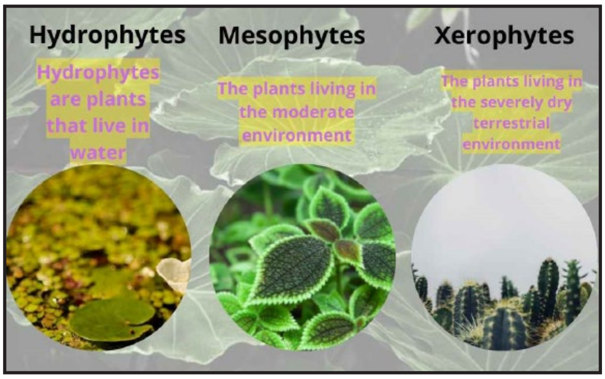
Limiting Factor

A **limiting factor** is a single environmental factor that can restrict the growth, distribution, or survival of an organism. It is the factor that is present in the lowest or most limiting quantity relative to the needs of the organism.

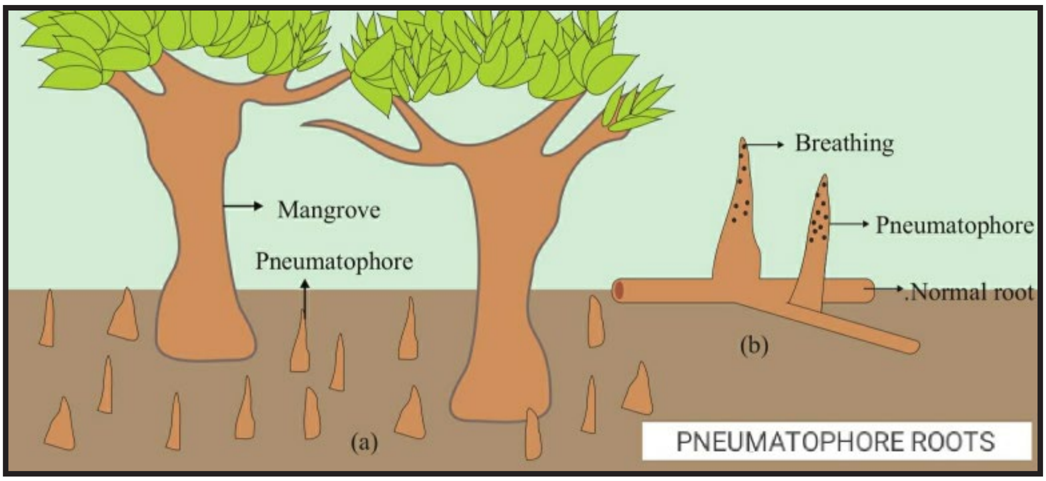
- For example, in a tropical rainforest, abundant rainfall and vegetation may seem favorable for seed germination. However, if the surface soil is heavily leached, leading to nutrient depletion, it becomes the limiting factor that hinders quick germination.
- Similarly, in a dense forest canopy, the absence of sufficient light may limit the growth and survival of saplings, making light availability the **limiting factor**.

Water

Water is a crucial abiotic component that impacts various aspects of an organism's life, especially in plant and aquatic ecosystems.



- **Hydrophytes:** Plants that are adapted to live in aquatic habitats. They possess special structures like aerenchyma or air-storing parenchyma that support them in water.
- **Mesophytes:** Terrestrial plants that are neither highly adapted to very wet nor very dry environments.
- **Xerophytes:** Plants found in dry areas that have developed modifications to increase water absorption and reduce transpiration to survive in arid conditions.
- **Halophytes:** Salt-tolerant plants that grow in high salinity environments such as mangroves, salt marshes, and saline semi-deserts.
- **Euryhaline and Stenohaline:** Organisms that can tolerate a wide range of salinities or are restricted to narrow salinity ranges, respectively.
- **Pneumatophores:** Specialized aerial root structures found in some plants growing in waterlogged conditions. They extend above the water surface to facilitate gas exchange between the atmosphere and submerged roots.



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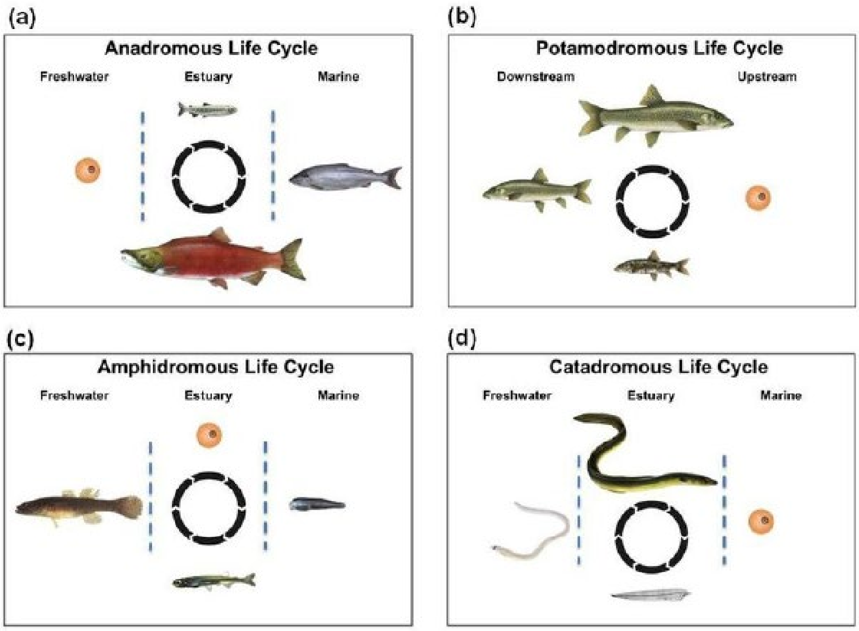


- **Catadromous and Anadromous Species:** Fish species that undergo migrations between freshwater and seawater for different life stages of their reproductive cycle.
- Some animals, like the **Kangaroo** and certain rodents in dry areas, do not drink water directly and obtain their water from the food they eat.

Light

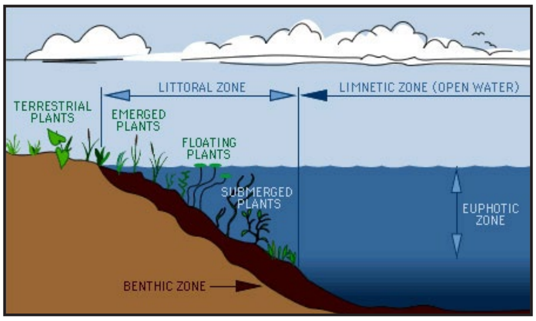
Light is a critical factor for photosynthesis and various other processes in plants and animals.

- **Diurnal**: Organisms that are active during the daytime.
- **Nocturnal**: Organisms that are active during the nighttime.
- **Auroral**: Organisms that are active at dawn or early morning.
- **Vesperal**: Organisms that are active at the time of dusk or sunset.

Photosynthesis, Growth, Transpiration, Germination, Pigmentation, Movements, Photoperiodism all are processes influenced by light in plants and animals.

- **Photoblastic seeds**: Seeds that require light for germination. They can be positively photoblastic (germinate better in light) or negatively photoblastic (germinate better in darkness).
- **Photonasty**: The phenomenon where flowers open or close in response to light and darkness.
- **Nyctinasty**: The folding of leaves in response to darkness.
- **Photomorphogenesis**: The process of differentiation of various tissues and organs in response to light.
- **Heliophytes**: Plants that are adapted to live under abundant sunlight, such as the banyan tree, which forms the roof of a forest.
- **Sciophytes**: Plants that are adapted to live under low light conditions, such as certain herbs, which form the understory of a forest.

Light Zones in Aquatic Habitat



- **Littoral zone**: The shallow coastal region of a water body where light can penetrate shallow water and reach the bottom.
- **Limnetic zone**: The open water zone of a lake or pond where the water is deep. The amount of light and oxygen decreases with depth.
- **Profundal/Aphotic zone**: The deep-water zone below the photic zone where light does not penetrate.
- **Benthic Zone**: The extreme bottom zone of an aquatic habitat where light does not reach, resulting in extreme darkness.

Rainfall: Rainfall provides the essential aqueous medium for a majority of biochemical reactions in living organisms.

Temperature

- **Temperature** influences various physiological functions and behaviors of organisms.
- **Eurythermal organisms** can tolerate a wide range of temperatures, while **stenothermal organisms** are restricted to a narrow range.
- High temperature can coagulate protoplasmic proteins and disrupt the balance between respiration and photosynthesis.
- **Growth, metabolism, reproduction, sex ratio, distribution, coloration, behavior, and morphology** are all affected by temperature.

Atmosphere

- The **atmosphere** consists of different gases that are essential for various processes in living organisms.

Terminology		Environmental factor
Stenothermal	Eurythermal	Temperature
Stenohaline	Euryhaline	Salinity
Stenoecious	Euryoecious	Habitat selection (niche)
Stenohydric	Euryhydric	Water
Stenophagic	Euryphagic	Food
Stenobathic	Eurybathic	Depth of water /habitat

- **Oxygen** (21%): Helps in the survival of many organisms.
- **Nitrogen** (78%): Prevents spontaneous combustion.
- **Carbon dioxide** (0.038%): Essential for the synthesis of carbohydrates by primary producers through photosynthesis.

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Organic and Inorganic Compounds

Organic compounds like proteins, carbohydrates, lipids, etc., are essential for energy transfer in the living world.

Inorganic compounds like carbon, carbon dioxide, water, sulphur, nitrates, phosphates, and various metal ions are essential for organisms to survive and carry out various biochemical processes.

Altitude

Altitude leads to vertical zonation of vegetation and affects temperature as a limiting factor.

Buffering Capacity of Earth

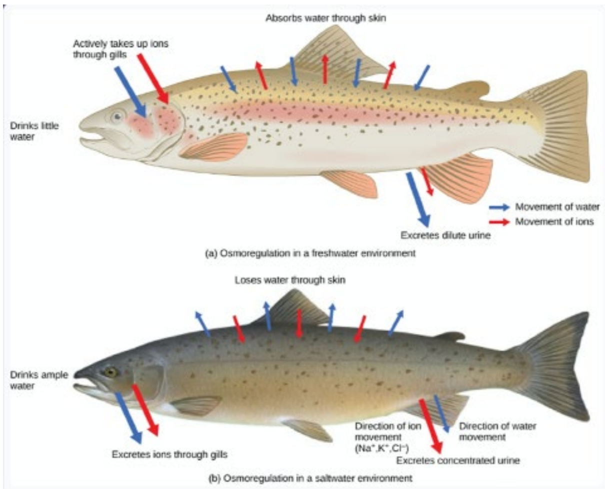
The earth's **buffering capacity** helps maintain a neutral pH in soil and water bodies, which is conducive to the survival and sustenance of living organisms.

Salinity

- **Euryhaline organisms** can tolerate a wide range of salinities, while **stenohaline organisms** are restricted to narrow salinity ranges.

Impact of Abiotic Components on Terrestrial Primary Producers (Plants)

- **Light Intensity**: Extremely high intensity may favor root growth over shoot growth, leading to increased transpiration and smaller, thicker leaves. Low light intensity can retard growth, flowering, and fruiting.
- **Frost** : Freezing of soil moisture can lead to increased transpiration and death of plants. Water in the intercellular spaces of the plant gets frozen into ice, leading to an increasing concentration of salts and dehydration of cells. Frost can also cause the formation of canker, which refers to various plant diseases with similar symptoms caused by a wide range of fungi, bacteria, and viruses.
- **Snow** (Continued): Snow acts as a protective blanket, preventing further temperature drop and protecting seedlings from excessive cold. However, accumulation of snow on tree parts can break branches or even uproot trees. Additionally, snow shortens the period of vegetative growth for plants.
- **Temperature**: High temperatures can result in the death of plants due to coagulation of protoplasmic proteins. Some bacteria can survive high temperatures because of their protoplasmic proteins that don't coagulate at such high temperatures. High temperature also disturbs the balance between respiration and photosynthesis. Furthermore, high temperatures cause desiccation of plant tissues and depletion of moisture.
- **Dieback**: Dieback refers to the progressive dying, usually starting from the tip and moving backward, of any portion of a plant. It is one of the adaptive mechanisms to avoid

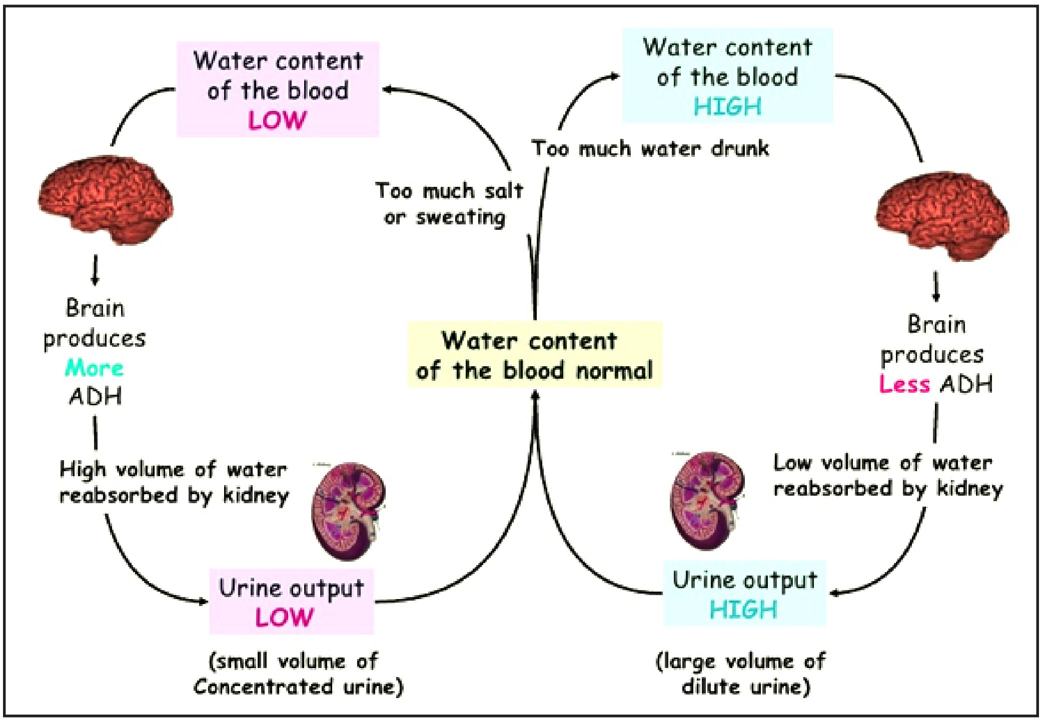


adverse conditions like drought. In this mechanism, the root remains alive for years together, but the shoots die. Examples of plants that exhibit dieback include sal, red sanders, silk cotton tree, etc.

Impacts of Abiotic Factors

Regulation

- **Homeostasis**: Homeostasis is the ability of animal organs and organ systems to constantly adjust to internal and external changes to maintain a steady state within the body. For example, humans sweat to cool down their body temperature when it's hot outside and shiver to generate heat when it's cold.
- **Osmoregulation**: Osmoregulation is the process by which organisms maintain the



balance of salt and water across their cell membranes and within their bodies. For instance, marine fish need to regulate the salt content in their bodies to prevent dehydration in the salty seawater.

- **Thermoregulation**: Thermoregulation is the ability of an organism to keep its body temperature within certain boundaries, even when the surrounding temperature varies significantly. Warm-blooded animals, like mammals and birds, can regulate their body temperature to cope with changes in the environment.

Migration

- **Drought Evaders**: Some organisms have developed strategies to cope with droughts. They may have a short annual life cycle, undergo aestivation (a state of dormancy during hot and dry periods), or enter other dormant states to survive until better conditions return.
- **Winter Migration**: Thousands of species of animals, birds, reptiles, and even insects participate in winter migration to seek food or warmer temperatures. For instance, many bird species from Siberia migrate to Keoladeo National Park in Rajasthan, India, during the winter months.

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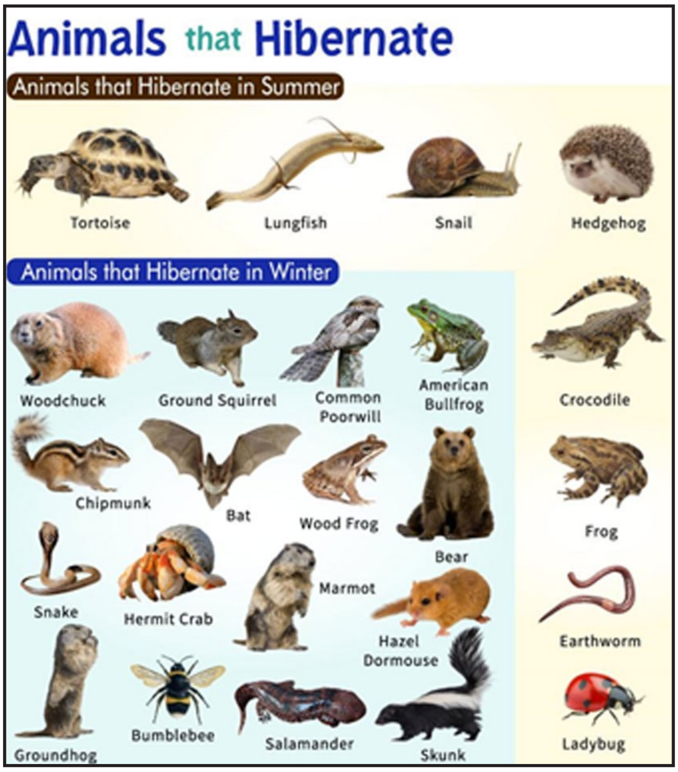
- **Migration due to Adverse Conditions**: Some animals that do not hibernate resort to migration to escape harsh environmental conditions.

Resistance

- **Dormancy**: Dormancy is a state of reduced activity and lowered metabolic rate in both animals and plants. During dormancy, organisms can survive adverse conditions like extreme temperatures or lack of resources. Seeds in soil, for example, remain dormant until favorable conditions trigger germination.
- **Diapause**: In animal dormancy, diapause is a delay in development in response to regularly and recurring periods of adverse environmental conditions. Insects, for example, may enter diapause to survive the winter.
- **Aestivation**: Some animals aestivate to avoid desiccation during hot and dry periods. This state of dormancy allows them to conserve water and energy until conditions improve.
- **Brumation**: Brumation is a state of dormancy in reptiles that resembles hibernation. Reptiles undergo brumation during late autumn and winter, reducing their activity and metabolic rate to cope with colder temperatures.
- **Hibernation**: Hibernation is a form of dormancy that animals use to conserve energy during winter when food is scarce. Animals in hibernation reduce their body temperature and slow down their metabolic processes.



Understanding and studying the impacts of abiotic factors on living organisms is crucial for ecological research and conservation efforts. It helps us comprehend the adaptations and strategies developed by different species to survive and thrive in their respective environments. Moreover, recognizing the limitations posed by these abiotic components aids in predicting the effects of environmental changes, such as global warming or habitat destruction, on biodiversity and ecosystem dynamics.

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Important Ecological Processes and Adaptations

Ecological Processes

- **Evolution** is the process of change leading to the emergence of new species, driven by adaptations to the environment.
- **Adaptations** are inherited modes of life that enable organisms to survive in their habitats.
- **Variations** arise from changes in genetic makeup due to mutations, climate changes, or geographical barriers.
- **Speciation** is the formation of new species, often resulting from geographic isolation.
- **Extinction** is the termination of a species, marked by the death of the last individual.
- **Natural Selection** is the mechanism proposed by Darwin and Wallace, wherein species adapt to their environment.

Ecological Adaptations

Types of Adaptations

- **Adaptations** are attributes (morphological, physiological, or behavioral) that help organisms survive and reproduce in their habitats.
- Examples of adaptations:
  - Desert plants have thick cuticles and stomata in deep pits to minimize water loss.
  - Mammals from colder climates have shorter ears and limbs to reduce heat loss (Allen's Rule).
  - Altitude sickness triggers physiological changes to compensate for low oxygen availability.
  - Lizards bask in the sun to regulate body temperature.
  - Biochemical responses in endotherms decrease metabolic efficiency to produce heat.
  - Ectotherms use mechanisms to tolerate or avoid ice crystal formation at temperatures below 0°C.

Ecological Adaptation Rules

- **Gloger's Rule**: Within a species of endotherms, more heavily pigmented forms are found in more humid environments.
- **Allen's Rule**: Animals adapted to cold climates have shorter limbs and bodily appendages than those in warm climates, depending on the habitat's average temperature.
- **Bergmann's Rule**: Populations and species of larger size are found in colder environments, while smaller sizes are found in warmer regions.
- **Rensch's Rule**: Sexual size dimorphism increases with increasing body size when males are larger and decreases with increasing size when females are larger.
- **Hamilton's Rule**: Closely related individuals have a greater potential genetic payoff, supporting natural selection for genetic success.
- **Shelford's Law of Tolerance**: Organisms' survival depends on a set of conditions with definite minimum, maximum, and optimum ecological factors.
- **Liebig's Law of Minimum**: Yield is proportional to the amount of the most limiting nutrient.

Understanding these ecological processes and adaptations is vital for comprehending the dynamics of ecosystems and the survival of species within their respective environments.

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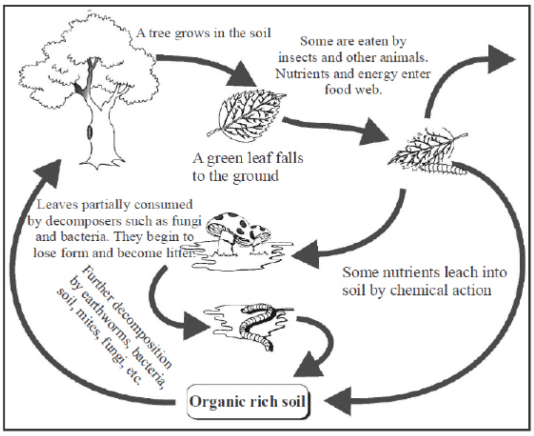
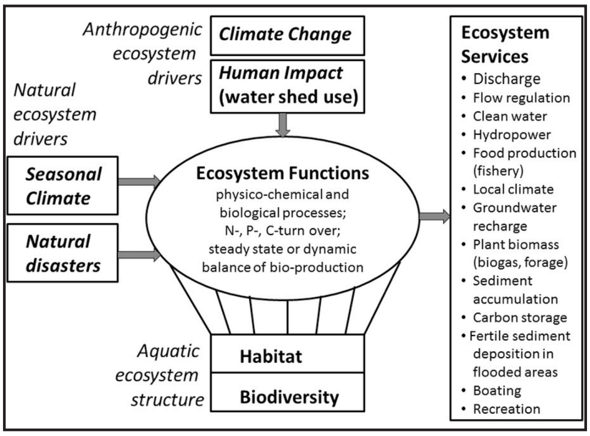
Functions of Ecosystem

Ecosystems serve **vital functions** that support life and maintain ecological balance. These functions are **interconnected** and play a **crucial role** in sustaining the **health and diversity** of the ecosystem.



1. **Ecological Succession and Stability**: Ecosystems undergo **ecological succession**, gradually evolving and adapting to environmental changes or disturbances. Despite these changes, ecosystems display remarkable **stability**, maintaining their structure and functions over time.
2. **Homeostasis and Feedback Mechanisms**: Ecosystems maintain **dynamic equilibrium** through **feedback control mechanisms**. These mechanisms regulate environmental conditions and prevent drastic fluctuations in population sizes, contributing to the overall **stability** and **sustainability** of the ecosystem.
3. **Energy Flow and Nutrient Cycling**: Ecosystems facilitate the transfer of **energy** from one organism to another through the **food chain**. Producers convert solar energy into **biomass**, supporting the growth of plants and providing food for other organisms in the ecosystem. Additionally, ecosystems continuously **recycle** and **redistribute** essential nutrients through **biogeochemical cycles** like the **nitrogen cycle**, ensuring their availability for different organisms and maintaining a **balanced nutrient cycle**.



4. **Decomposition and Recycling**: Ecosystems play a vital role in **decomposition**, breaking down dead organic matter into simpler substances through **decomposers**. This process recycles nutrients back into the soil, making them available for new growth and sustaining the nutrient supply within the ecosystem.
5. **Support of Life and Habitats**: Ecosystems provide **habitats, food, water**, and other essential resources for the **survival and well-being** of diverse species. They create a conducive environment for various organisms, contributing to the overall **support of life** on Earth.

Understanding these functions is critical for effective conservation and **sustainable management** of ecosystems. Human activities that impact these functions can have far-reaching consequences on the delicate balance of nature. By appreciating the **interconnectedness** of these functions, we can make informed decisions to **protect and preserve** ecosystems for the benefit of current and future generations.

Ecological Succession

- Ecological succession is the process of **changing plant and animal communities** over time in an area.
- It occurs due to large-scale changes or destruction, either natural or man-made.
- The process involves a series of changes, with one community replacing another until a stable, **climax community** develops.
- There are two types: **Primary Succession** (on new areas) and **Secondary Succession** (after destruction).

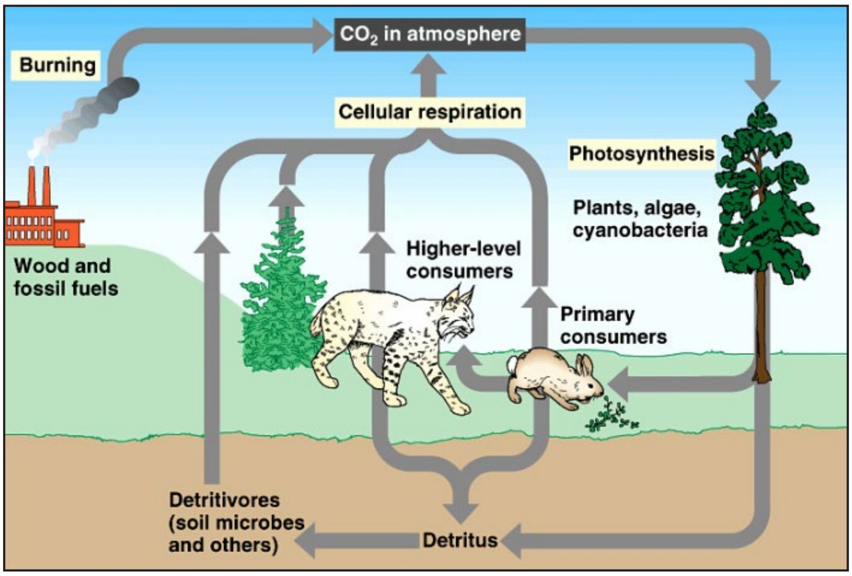
Homeostasis in Ecosystem

- Homeostasis is the **maintenance of stable equilibrium** in an ecosystem.
- Organisms try to maintain constancy of their internal environment despite varying external conditions.
- Some organisms can regulate their internal environment through physiological means, while others simply **conform** to external conditions.
- Organisms may also **migrate**, **suspend**, or **escape** in time to avoid stressful conditions.
- When succession is brought about by living inhabitants (biotic components) of that community itself, the process is called **autogenic succession**, while change brought about by outside forces (abiotic components like fire, flood) is known as **allogenic succession**.

Ecosystem's Homeostasis

- Ecosystems have the capacity for **self-regulation** known as homeostasis.
- They can maintain equilibrium, regulate species structure, and functional processes.
- Ecosystems use **negative feedback mechanisms** to maintain stability.
- However, the homeostatic capacity of ecosystems is not unlimited, and not everything is always well-regulated.

Ecosystem Dynamics: Understanding Changes and Interactions



Ecosystem dynamics encompass the complex changes and interactions that occur within an **ecosystem** over time. It involves the study of the interplay between **living**

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organisms and their **environment**, influencing the overall structure and functioning of the ecosystem.

Key Aspects of Ecosystem Dynamics

1. **Succession**

- **Ecological succession** is the process of **ecosystem transition** from one stage to another.
- *Primary Succession*: Occurs in **newly formed** or **barren habitats** where **pioneer species** gradually colonize and pave the way for other species to establish.
- *Secondary Succession*: Takes place in **disturbed habitats** with retained soil and some organisms, as different species replace one another until a **stable climax community** is established.

2. **Population Dynamics**

- **Populations of organisms** within ecosystems undergo changes in **size, density, and distribution**.
- Factors such as **birth rates**, **death rates**, **immigration**, and **emigration** influence population dynamics.
- Interactions like **predator-prey relationships**, **competition for resources**, and **habitat availability** play a role in shaping population dynamics.

3. **Nutrient Cycling**

- Ecosystems involve the **cycling of nutrients** between **living organisms** and the **abiotic environment**.
- Nutrients like **carbon**, **nitrogen**, and **phosphorus** are absorbed by **plants** and transferred through the food chain as organisms consume each other.
- **Decomposers** break down organic matter, releasing nutrients back into the soil or water for uptake by plants, crucial for ecosystem functioning.

4. **Energy Flow**

- **Energy flows** in a **one-way direction** through ecosystems, starting with **solar energy** captured by **producers** (plants or algae) through **photosynthesis**.
- Producers transfer this energy to **consumers** (herbivores, carnivores, omnivores) during feeding.
- Energy is lost as **heat** at each **trophic level**, influencing the structure and dynamics of the food web.

5. **Disturbances**

- Ecosystems are subject to various **disturbances**, both **natural** and **human-induced**.
- Natural disturbances include **wildfires**, **floods**, **storms**, and **disease outbreaks**, while human-induced disturbances result from **deforestation**, **pollution**, **habitat fragmentation**, and **climate change**.
- Disturbances can have **short-term** and **long-term effects**, altering species composition, nutrient cycling, and overall ecosystem functioning.

Understanding ecosystem dynamics is essential for **ecosystem management** and **conservation efforts**. It allows us to comprehend the **resilience of ecosystems** to change and the potential impacts of **human activities**, guiding strategies to maintain their health and sustainability.

Energy Flow Through an Ecosystem – Trophic Levels

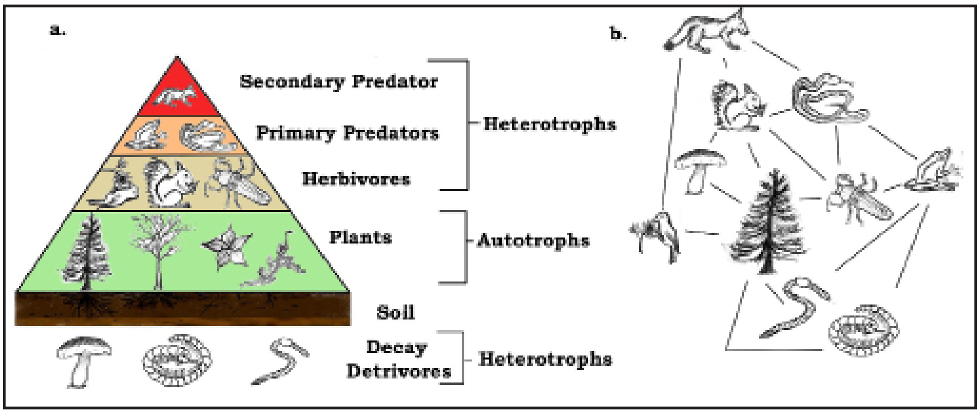
Energy flow in an ecosystem is represented by trophic levels, which illustrate the transfer of energy from one organism to another in a food chain. These trophic levels are interconnected, forming food webs that depict the complex feeding relationships within the ecosystem.

Introduction to Trophic Levels

- **Trophic levels** represent **energy flow** in an **ecosystem**.
- Each organism occupies a position in a **food chain** as its **trophic level**.
- **Trophic level interaction** is based on **nutritional needs** and connections among **ecosystem members**.

Trophic Levels and Organisms

- **Autotrophs (Producers)**: Green plants that produce their own food.
- **Heterotrophs (Primary Consumers)**: Herbivores that consume producers.
- **Heterotrophs (Secondary Consumers)**: Carnivores that consume primary consumers.
- **Heterotrophs (Tertiary Consumers)**: Carnivores that consume secondary consumers.
- **Heterotrophs (Quaternary Consumers)**: Top carnivores that consume tertiary consumers.

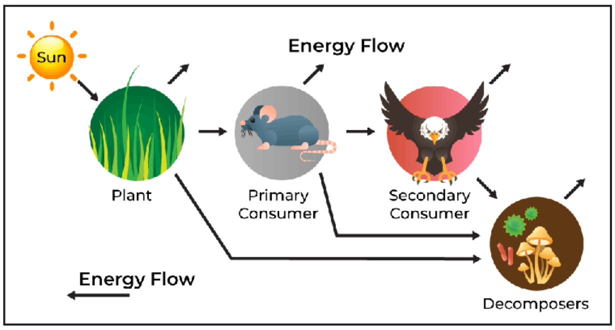


Unidirectional Energy Flow

- **Energy flows** from producers to subsequent trophic levels.
- Energy **decreases** at each trophic level due to **heat loss**, making higher levels less energy-rich.
- Usually, there are not more than **four-five trophic levels** as the energy becomes negligible to support organisms beyond this.

Trophic Level Interaction

- Three concepts involved in **trophic level interaction**:
  1. **Food Chain**: Represents the transfer of **food energy** from producers to consumers in a linear sequence.



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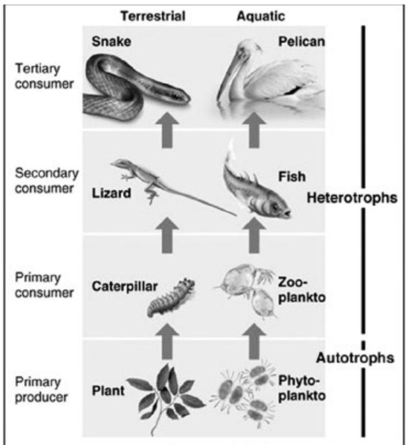
2. **Food Web**: Multiple interlinked food chains that show all possible energy flow paths in an ecosystem.
3. **Ecological Pyramids**: Represent the trophic structure and energy flow in an ecosystem.

Food Chain

- Sequential transfer of **food energy** from producers to consumers.
- Each step in the **food chain** is a trophic level.
- Types of Food Chains: **Grazing food chain** and **Detritus food chain**.

Grazing Food Chain

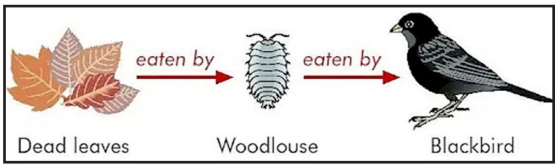
- Begins with consumers that eat plants or plant parts.
- Example: Grass → Grasshopper → Frog → Snake → Hawk/Eagle.
- Significant conduit for energy flow in **aquatic ecosystems**.



Grazing Food Chain

Detritus Food Chain

- Starts from organic matter of **dead and decaying** organisms from the grazing food chain.
- **Detrivores or decomposers** break down dead organic matter into inorganic substances.
- More energy flows through this chain in **terrestrial ecosystems** compared to grazing food chain.

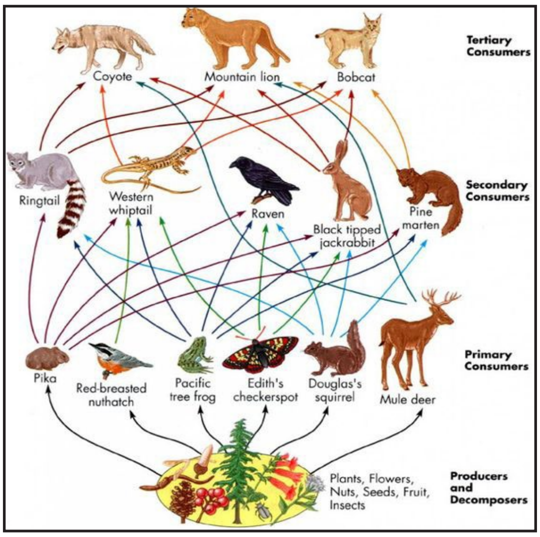


Decomposers

- **Decomposer organisms** break down organic matter into simple inorganic substances.
- **Fungi** and **Bacteria** are examples of decomposers.
- **Viruses** and **Protists** are not decomposers.

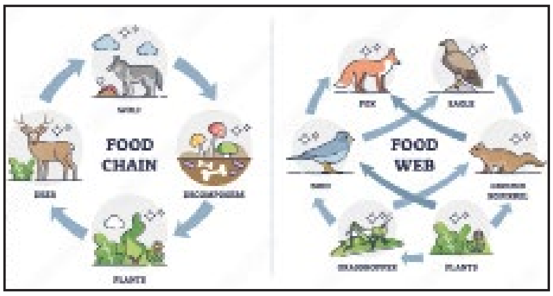
Food Web

- A network of interconnecting food chains in a natural community of different organisms. The food web begins with plants and ends with the top carnivore.
- A network of interconnected food chains in a natural community.
- Represents multiple energy flow paths in an ecosystem.
- Increased chance of survival for organisms due to multiple alternatives for food.



Complex Interconnections

- Food webs show all possible transfers of energy and nutrients among organisms in an ecosystem.
- The interconnected nature of food webs ensures better chances of survival for organisms, as they have multiple food sources.



Dynamic and Seasonal Nature: Food availability and preferences shift seasonally, leading to changes in food web dynamics.

FOOD CHAIN vs FOOD WEB		
Theme	Food Chain	Food Web
Definition	Linear transfer of food energy	Interconnected feeding relationships
Structure	Single energy flow path	Network of interconnecting routes
Complexity	Relatively simple	More complex
Representation	Sequential organism eating sequence	Multiple interconnected food chains
Trophic Levels	Producers, consumers	Grouping into trophic levels
Impact of Disruption	Disruption in one level affects the whole chain	Disruption may not affect the entire web
Adaptability	Limited food sources	Multiple food sources
Significance	Basic energy flow understanding	Comprehensive species interactions
Application	Energy transfer study	Understanding stability and dynamics

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Types of Biotic Interactions in a Food Web

'0' is no effect; '–' is detrimental; '+' is beneficial.

Interaction Among Biotic Factors			
Interaction Type	**Species 1**	**Species 2**	**Detailed Effect(s)**
Neutralism	0	0	⌘ Neither species affects the other. ⌘ True neutralism is extremely unlikely.
Competition	-	-	⌘ Direct inhibition of each species by the other. ⌘ Competition is the struggle between two organisms for the same resources within an environment.
Amensalism	-	0	⌘ Amensalism meaning, an ecological interaction between two species, but in this association among organisms of two different species, one is destroyed or inhibited, and other remains unaffected.
Parasitism	+	-	⌘ Parasitism is a symbiotic relationship between species, where one organism, the parasite, lives on or inside another organism, the host, causing it some harm, and is adapted structurally to this way of life. ⌘ Many parasites have evolved to be host-specific (they can parasitize only a single species of host) in such a way that both host and the parasite tend to co-evolve.
Predation	+	-	⌘ Predation is a biological interaction where one organism, the predator, kills and eats another organism, its prey. ⌘ Predators also help in maintaining species diversity in a community.
Commensalism	+	0	⌘ Population 1, the commensal, benefits while the population 2. The host is not affected. ⌘ Commensalism is a long-term biological interaction in which members of one species gain benefits while those of the other species neither benefit nor are harmed.
Protocooperation	+	+	⌘ Interaction favourable to both but not obligatory.
Mutualism	+	+	⌘ Interaction favourable to both and obligatory.

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ECOLOGICAL PYRAMIDS

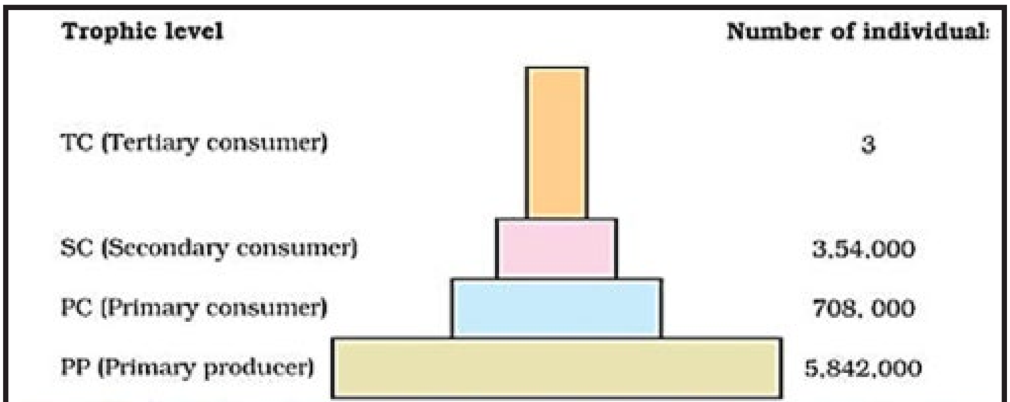
Definition and Structure of Ecological Pyramids

- Ecological pyramids represent **trophic levels** in an ecosystem using a diagrammatic approach.
- The pyramid's **base** represents the **food producers**, and the **tip** represents the **top carnivores**, with other **consumer** trophic levels in between.
- The **length** of each horizontal bar in the pyramid indicates the **total number** of **individuals** at each trophic level.
- The **number**, **biomass**, and **energy** of organisms decrease with each step from the **producer** level to the **consumer** level, giving the pyramid its characteristic shape.

Three Categories of Ecological Pyramids

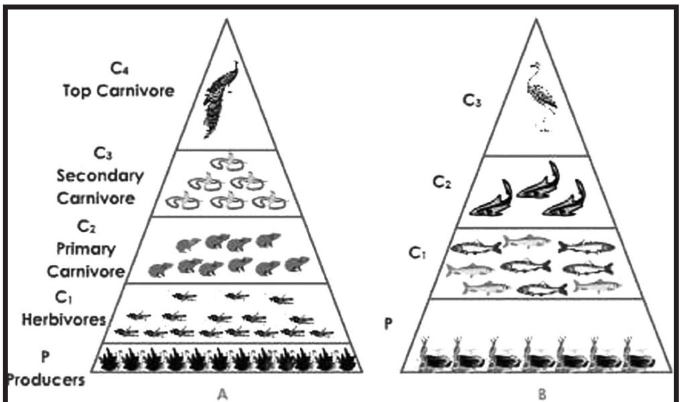
1. Pyramid of Numbers

- Represents the **total number** of **individuals** of different species at each trophic level.
- May be **upright** or **inverted** depending on the ecosystem's characteristics.



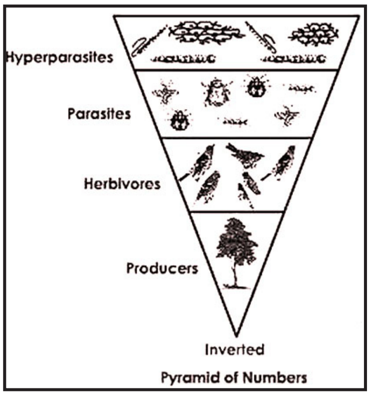
Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants

- **Upright Pyramid:** Number of individuals **decreases** from lower to higher trophic levels, common in grassland and pond ecosystems.



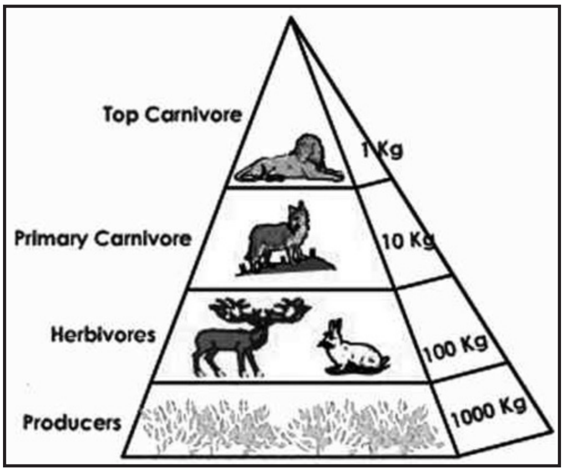
Upright Pyramids of Numbers. (A) In a Grass Land (B) In a Pond

- **Inverted Pyramid:** Number of individuals **increases** from lower to higher trophic levels, found in certain tree ecosystems.

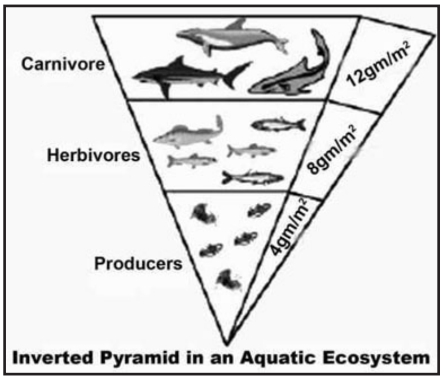


2. Pyramid of Biomass

- Overcomes the limitations of the pyramid of numbers by representing the **total dry weight** of organisms at each trophic level.
- Determined by **weighing** individuals at each trophic level, allowing consideration of organism **size** differences.
- **Upright Pyramid:** Common in terrestrial ecosystems, with a large base of **primary producers** and **decreasing** biomass at higher trophic levels.

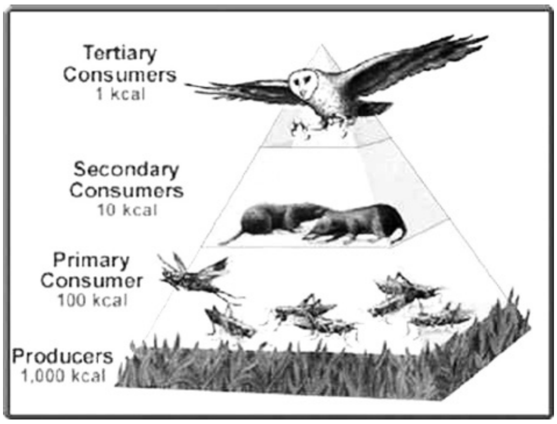


- **Inverted Pyramid:** Found in some aquatic ecosystems due to rapid-reproducing **phytoplankton**.



3. Pyramid of Energy

- Represents the **amount of energy** at each trophic level and the **loss of energy** with each transfer to higher trophic levels.
- Always **upright** due to the **decreasing** usable energy from **sunlight** to **producers**, **herbivores**, and **carnivores**.
- Demonstrates the **10% energy rule**, where only a fraction of energy is transferred to the next trophic level.

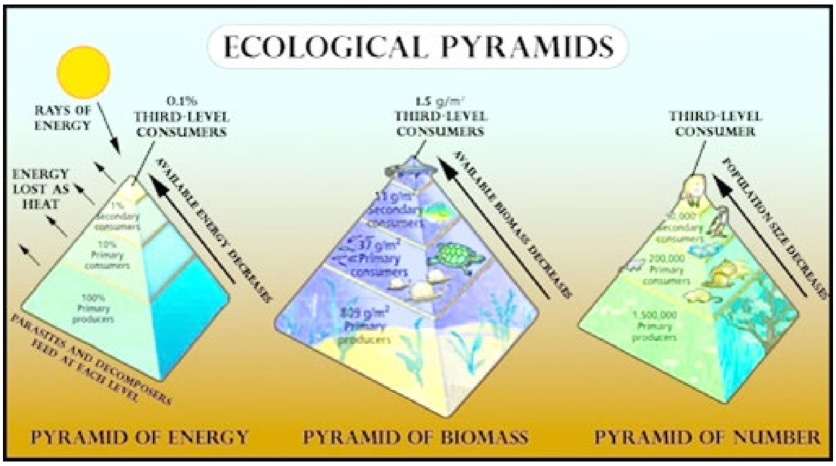


Ecological Efficiency

- Describes the **efficiency** of energy transfer between trophic levels.
- Follows the **10% energy rule**, limiting the number of trophic levels in a grazing food chain.
- Efficiency **decreases** due to energy loss through **respiration** and **transformations**.
- The decreases at each subsequent trophic level is due to two reasons:
  - At each trophic, a part of the available energy is lost in respiration or used up in metabolism.
  - A part of the energy is lost at each transformation

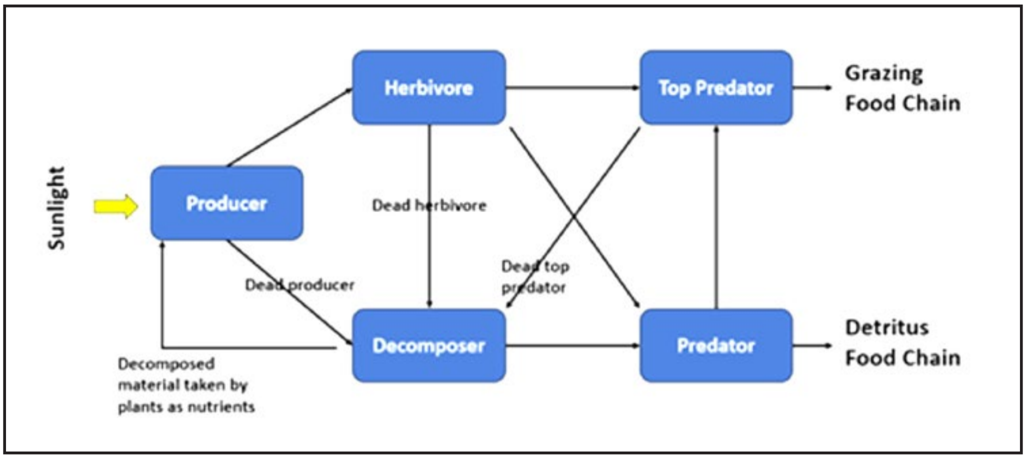
Limitations of Ecological Pyramids

- Fails to account for the same species belonging to **multiple** trophic levels.
- Assumes **simple** food chains, overlooking **complex** food webs.
- Omits **saprophytes**, important decomposers, from the pyramid, despite their vital role in ecosystems.



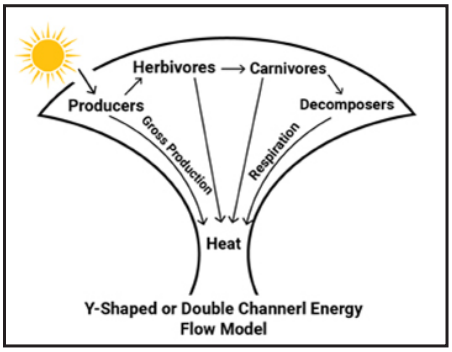
Models of Energy Flow in Ecosystems

1. **Linear Energy Flow Model or Single Channel Energy Flow Model:**



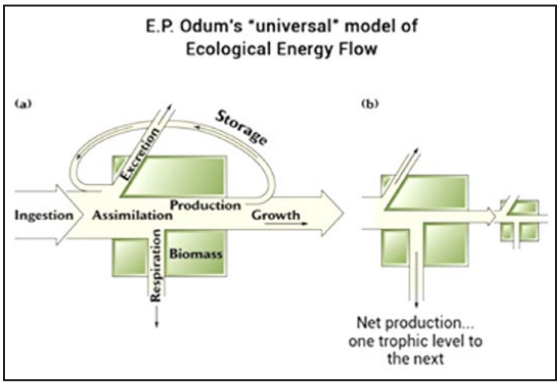
- Represents the **unidirectional flow** of energy through a **food chain** in an ecosystem.
- Energy flows from **producers (plants)** to **herbivores**, then to **carnivores**, and so on.
- **No recycling** of energy; it moves along the food chain.

2. **Y-shaped or Double Channel Energy Flow Model:**



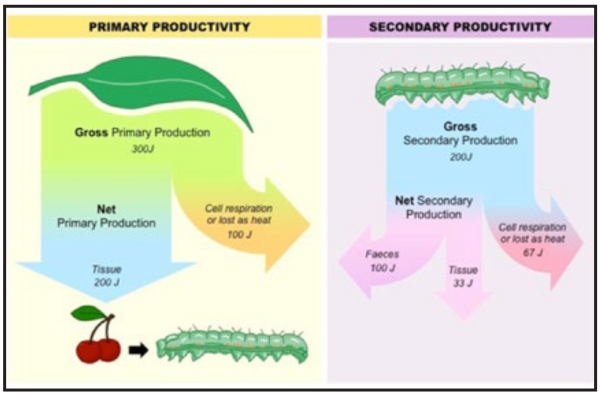
- Depicts interconnectedness of **grazing** and **detritus food chains**.
- Both contribute to energy flow.
- Grazing: **Living plants** -> **herbivores**; Detritus: **Dead organic matter** -> **detritivores** and **decomposers**.

3. Universal Energy Flow Model:



- Developed by H.T. Odum, a **comprehensive framework**.
- Includes **plants, animals, microorganisms**, and more.
- Visualizes **complex relationships** and interactions.
- Uses interconnected boxes for **energy acquisition, utilization, and transfer** within the ecosystem.

Ecological Productivity



- Ecological productivity refers to the capacity of an ecosystem to produce and accumulate organic matter through photosynthesis and other biological processes. It is a measure of the ecosystem's energy and biomass production.
- Productivity in an ecosystem is the rate at which biomass is produced or accumulated. It can be categorized into two types: primary productivity and secondary productivity.

Here's a breakdown of each type:

Primary Productivity:

- Primary productivity refers to the production of biomass by autotrophic organisms, primarily through photosynthesis.
- Gross primary productivity (GPP) measures the total amount of energy captured by autotrophs through photosynthesis.
- Net primary productivity (NPP) represents the energy available for consumption by heterotrophic organisms after subtracting the energy used by autotrophs for their own respiration.
- NPP is a crucial measure as it determines the amount of energy available to support higher trophic levels in the ecosystem.

Secondary Productivity:

- Secondary productivity is the accumulation of biomass by heterotrophic organisms, such as animals, fungi, bacteria, and protists.
- It occurs as energy is transferred from one trophic level to another through the consumption of organic materials.
- Secondary productivity is influenced by factors such as food availability, reproductive rates, and energy transfer efficiency between trophic levels.

Unit of Productivity:

- Productivity is commonly expressed as mass per unit area per unit time, such as grams per square meter per year ($g/m^2/year$) or kilograms per hectare per year (kg/ha/year).
- These units represent the amount of biomass produced within a given area over a specific time period.

POLLUTANTS AND TROPHIC LEVEL

Introduction to Pollutants and Trophic Level

- **Pollutants**, especially **non-degradable** ones, move through different **trophic levels** in an ecosystem.
- **Non-degradable pollutants** cannot be broken down by living organisms and tend to persist in the environment.

Chlorinated Hydrocarbons (CHC)

- **CHCs** are hydrocarbons in which one or more hydrogen atoms have been replaced by chlorine, such as **DDT**, endosulfan, chloroform, carbon tetrachloride, etc.
- They have various applications, including use in **polyvinyl chloride production**, as **solvents**, and as **pesticides**.

Effects of CHCs

- Some CHCs like **DDT** are **persistent organic pollutants** (POPs) that can cause harm to organisms and accumulate in food chains.
- DDT usage was phased out in many countries due to its negative impacts on certain bird species.
- However, traces of DDT and other CHCs can still be found in the environment and in mammals, including humans.

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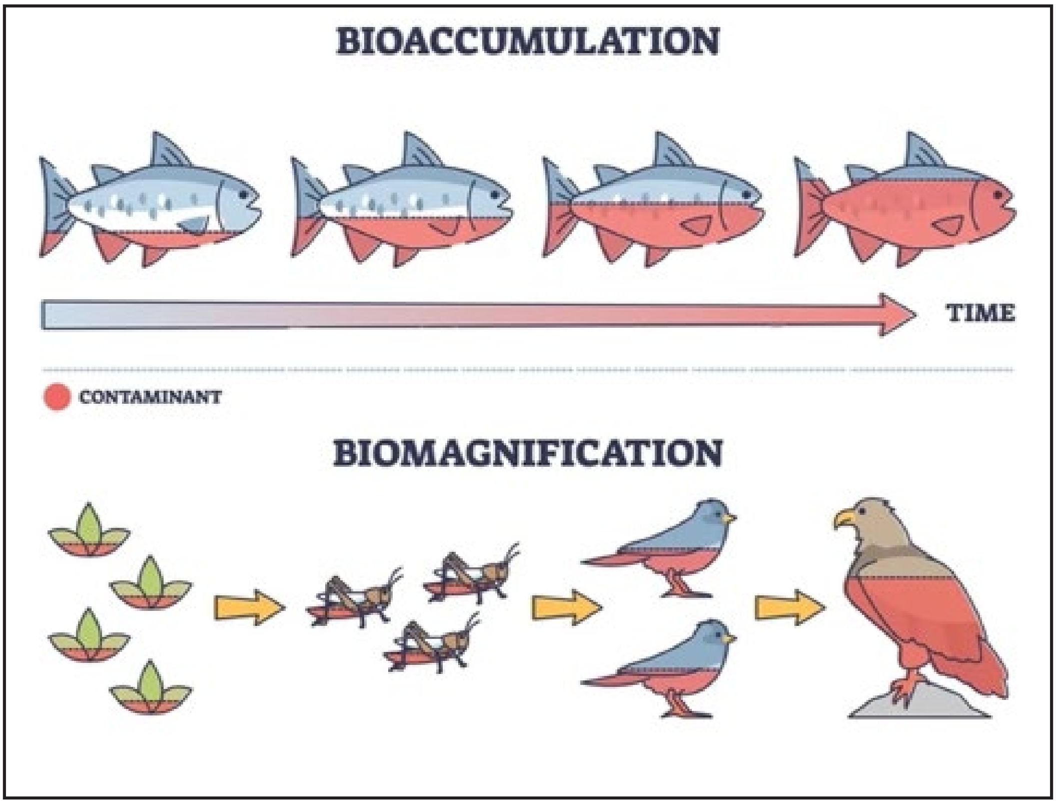
Bioaccumulation



Bioaccumulation

- Bioaccumulation refers to the net accumulation of contaminants in or on an organism from various sources, such as water, air, and diet.
- It occurs when an organism takes in a substance at a faster rate than it can eliminate it, leading to the buildup of the substance within the organism's body.
- Bioaccumulation is a concern when the accumulated substance is toxic, as it can result in chronic poisoning and adverse effects on the organism's health.

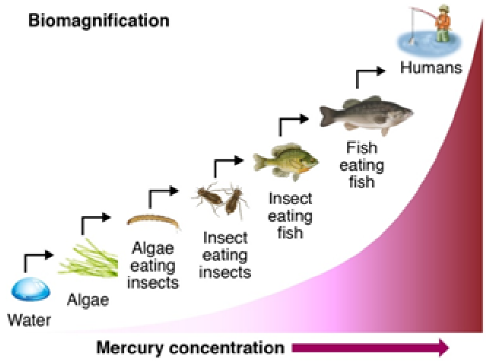
Examples:

- Car emission pollutants accumulating in birds and other animals.
- Rising mercury levels in fish due to mercury pollution.
- Pesticides building up in the bodies of small animals.

Causes:

- Release of toxic chemicals and pollutants into the environment, leading to their presence in soils, water bodies, and the atmosphere.
- Gradual accumulation of harmful substances in lower-level organisms of the food chain, such as fish, plants, and insects.
- Biomagnification, where toxins are passed up the trophic levels as higher-level organisms consume those at lower levels, leading to a concentration of toxins in the higher-level organisms.

Bio-magnification



- Biomagnification stands for Biological Magnification, which refers to the growth of tainted or harmful compounds in food chains.
- Intoxicated or contaminated settings are common sources of these chemicals.
- Heavy metals such as mercury and arsenic, pesticides such as DDT, and polychlorinated biphenyls (PCBs) are among the contaminants that are taken up by organisms as a result of the food they eat or the poisoning of their surroundings.
- These substances can be found in a wide range of household and industrial compounds.
- The toxic compounds then accumulate within the cells of the organism.
- Toxins are gradually concentrated in the higher food chain as species in the higher food chain feed organisms bearing the toxins below their trophic levels.
- The higher organisms will accumulate the majority of the toxins because this is a repeating process in the ecosystem and along the entire food chain.

Causes of Bio-magnification

- Toxic chemicals and pollutants are released into the environment, resulting in an accumulation of toxins and dangerous substances in the oceans, air, and land.
- When harmful chemicals and pollutants are discharged in different settings, their concentrations appear to be very low, but they gradually accumulate and are absorbed by lower creatures in the food chain, such as fish, earthworms, and plants.
- Biomagnification happens when lesser species are eaten by higher animals, and the process continues up the trophic levels.

Agriculture:

- Agricultural chemicals like pesticides, fungicides, and herbicides contaminate soils and water bodies.
- Heavy metals from fertilizers and industrial waste can also contribute to biomagnification.

Organic Contaminants:

- Nitrogen, carbon, phosphorus, and pollutants from manures and biosolids can lead to biomagnification.
- Personal care products (PPCPs) and medications can also be found in human and animal bodies.

Industrial Manufacturing Activities and Pollution:

- Industries release harmful compounds into the environment, contaminating soils, rivers, and oceans.

Mining Activities in the Ocean:

- Deep-sea mining for minerals and metal ores leads to toxic deposits that affect marine species.

Effects of Bio-magnification

Impact on Human Health:

- Mercury, cadmium, lead, and other toxins can lead to cancer, organ failure, respiratory illnesses, and birth defects.
- Effects on Reproduction and Development of Marine Creatures:
- Accumulated toxic substances can impair reproduction and development in aquatic species, affecting their survival.

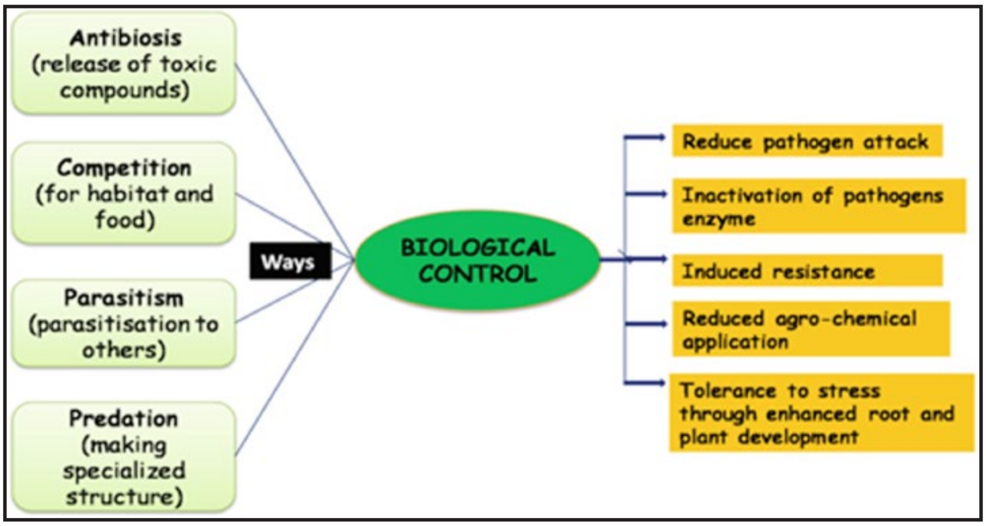
Destruction of Coral Reefs:

- The use of cyanide in gold leaching and fishing destroys coral reefs, disrupting the habitat of various marine creatures.

- Pollutants that do not degrade pose significant risks to ecosystems through **bioaccumulation** and **biomagnification**.
- Monitoring and regulating the use of such pollutants are crucial to safeguarding the health of both wildlife and humans.

Themes	Bioaccumulation	Bio-magnification
Definition	The net accumulation of contaminants in or on an organism from various sources, including water, air, and diet.	The process where toxins are passed up the food chain, leading to an increase in concentration at higher trophic levels.
Mechanism	Organisms take in substances at a faster rate than they can eliminate them, resulting in a buildup of the substance in their bodies.	Toxins are transferred from one organism to another as predators consume prey, leading to a concentration of toxins in higher-level consumers.
Focus	Accumulation of contaminants in individual organisms.	Concentration of toxins at different trophic levels in a food chain or food web.
Source of Contaminants	Comes from various sources, including water, air, and the organism's diet.	Initially introduced into the environment through human activities, such as industrial pollution and the use of pesticides.
Impact on Organisms	Can lead to chronic poisoning and adverse effects on an organism's health.	Higher-level consumers may experience greater toxic effects due to the higher concentration of toxins in their bodies.
Ecological Significance	Important for understanding how contaminants affect individual organisms and their populations.	Provides insights into how toxins are transferred and magnified within ecosystems, affecting the entire food chain.
Examples	- Car emission pollutants accumulating in birds and animals. - Mercury buildup in fish due to mercury pollution. - Pesticides building up in small animal bodies.	- Mercury biomagnifying in the food chain, impacting top predators like birds and humans. - Pesticides accumulating in higher-level consumers, leading to increased toxicity.

Biological Control



Biological Control: An Eco-Friendly Pest Management Strategy

Definition of Biological Control

- **Biological control** or **biocontrol** is a pest management method that involves using **natural enemies** to control pest populations and invasive species.
- It is a sustainable and eco-friendly approach utilized in **agricultural, horticultural, and natural ecosystems** to maintain ecological balance.

Types of Biological Control

1. **Classical Biological Control**
   - Involves introducing natural enemies from the pest's **native habitat** to control its population in a new area.
   - **Careful selection and testing** ensure the introduced species do not become pests themselves.

2. **Augmentative Biological Control**

   - Releasing large numbers of **mass-produced natural enemies** to control existing pest populations, especially when numbers are high and require immediate reduction.

Natural Enemies in Biological Control

- **Predators**: Organisms that consume and kill pests directly, e.g., ladybugs, lacewings, and predatory mites.
- **Parasitoids**: Insects that lay their eggs inside or on the host pest, and the emerging larvae consume the host from within, eventually killing it.
- **Pathogens**: Disease-causing organisms, such as bacteria, viruses, and fungi, that infect and kill pests.

Advantages of Biological Control

- **Environmentally Friendly**: Reduces the need for chemical pesticides, thus minimizing environmental pollution.
- **Target-Specific**: Natural enemies often target specific pests, sparing non-target organisms from harm.
- **Sustainable**: Once established, natural enemies provide long-term pest control.
- **Cost-Effective**: Economically viable, especially when natural enemies are already present or can be easily introduced.

Limitations of Biological Control

- **Time-Consuming**: It may take time for natural enemies to establish and achieve effective pest control.
- **Site-Specific**: The success of biological control can depend on specific environmental conditions.
- **Risks of Non-Target Effects**: Introducing non-native natural enemies may cause unintended consequences on local ecosystems.

Examples of Biological Control

- Ladybugs and green lacewings controlling aphids in agricultural crops.
- Trichogramma wasps parasitizing the eggs of corn borers.
- Baculoviruses infecting and killing caterpillar pests.

Integration with Other Pest Management Practices

- Biological control is often used in conjunction with other pest management strategies, such as cultural practices, crop rotation, and use of resistant plant varieties, in Integrated Pest Management (IPM) programs.

Importance of Biological Control

- Plays a crucial role in promoting **sustainable agriculture**, conserving biodiversity, and reducing the ecological impact of pest control practices.
- An essential tool for **maintaining ecosystem balance** and ensuring **food security**.

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Organic Farming

Definition of Organic Farming

- Organic farming is a **sustainable and environmentally-friendly agricultural practice** that avoids the use of synthetic chemicals and genetically modified organisms (GMOs).
- It emphasizes **natural processes** and aims to promote soil health, biodiversity, and overall ecosystem well-being.

Principles of Organic Farming

1. **No Synthetic Chemicals**
   - Prohibits the use of synthetic fertilizers, pesticides, herbicides, and other chemical inputs.
   - Relies on **natural alternatives** to manage pests and enhance soil fertility.
2. **Soil Health**
   - Focuses on building and maintaining healthy, fertile soils through practices like composting, crop rotation, cover cropping, and minimal soil disturbance.
3. **Biodiversity**
   - Encourages biodiversity by providing habitats for beneficial insects, birds, and wildlife.
   - Promotes crop diversity and mixed farming systems to reduce the risk of pest outbreaks and improve resilience.
4. **Animal Welfare**
   - Puts strong emphasis on the humane treatment of animals, providing them with access to open spaces, natural diets, and avoiding unnecessary use of antibiotics or growth hormones.

Practices in Organic Farming

- **Crop Rotation**: Growing different crops in a planned sequence to break pest cycles, improve soil health, and reduce soil-borne diseases.
- **Composting**: Converting organic matter from plant and animal sources into nutrient-

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rich compost to enhance soil fertility and structure.

- **Cover Cropping**: Planting cover crops during fallow periods to add organic matter to the soil, prevent erosion, and suppress weed growth.
- **Biological Pest Control**: Encouraging beneficial insects, birds, and other organisms to naturally control pest populations.
- **Integrated Weed Management**: Using methods like hand-weeding, mulching, and cultivation to manage weeds without chemical herbicides.
- **Non-GMO Seeds**: Relying on non-GMO seeds and avoiding the use of genetically modified organisms.
- **Certification**: Subject to strict certification standards to ensure compliance with organic principles and practices. Periodic inspections are required for organic certification.

Organic Farming: Products and Certification in India

- In India, organic food regulation is overseen by the Food Safety and Standards Authority of India (FSSAI).
- To be labeled as "organic" in India, food products must be certified under one of the following systems: Participatory Guarantee System for India (PGS-India) and National Programme for Organic Production (NPOP).
- Both systems have specific standards and guidelines governing organic food production and certification.

Benefits of Organic Farming

- **Environmental Protection**: Reduces the use of synthetic chemicals, minimizing soil and water contamination and promoting biodiversity.
- **Improved Soil Health**: Enhances soil fertility, structure, and water retention, leading to sustainable and long-term agricultural productivity.
- **Safer Food**: Organic produce is free from synthetic pesticides and residues, making it safer for consumers.
- **Climate Resilience**: Contributes to climate change mitigation by sequestering carbon in the soil and reducing greenhouse gas emissions.

Challenges of Organic Farming

- **Lower Yields**: Organic farming may have lower yields initially, especially during the transition from conventional practices.
- **Market Demand**: Meeting the growing demand for organic products can be challenging for some farmers.
- **Pest Management**: Controlling pests without synthetic chemicals requires careful planning and continuous monitoring.

Importance of Organic Farming

- Promotes **environmental sustainability**, biodiversity conservation, and protection of natural resources.
- Focuses on **soil health** and ensures safer, chemical-free food for consumers.
- Contributes to **climate change mitigation** and supports long-term economic viability for farmers.