An **ecosystem** is a structural and functional unit of ecology. an ecosystem is a chain of interactions between organisms and their environment

Structure of the Ecosystem

The structure of an ecosystem is characterized by the organization of both biotic and abiotic components. This includes the distribution of energy in our environment.

The structure of an ecosystem can be split into two main components, namely:

- Biotic Components
- Abiotic Components

The biotic and abiotic components are interrelated in an ecosystem. It is an open system where the energy and components can flow throughout the boundaries.

Biotic Components

Biotic components refer to all living components in an ecosystem. Based on nutrition, biotic components can be categorized into autotrophs, heterotrophs and saprotrophs (or decomposers).

- Producers include all autotrophs such as plants. They are called autotrophs as they can produce food through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- Consumers or heterotrophs are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.
- Herbivores (Primary consumers) are always herbivores as they rely on producers for food. Eg. Rabbit, Cows etc.
- Carnivores (Secondary consumers) depend on primary consumers for energy. Eg. Lizard, Fox etc.
- Top Carnivores (Tertiary consumers) are organisms that depend on secondary consumers for food. Tertiary consumers can also be carnivores or omnivores.
- Quaternary consumers are present in some food chains. These organisms' prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.
- Decomposers include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants

Abiotic Components

Abiotic components are the non-living component of an ecosystem. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc.

Inorganic substances which are involved in mineral cycles. Ex: C, N, P, K, S, H etc.

Organic substances present in the biomass or in the environment. They form the living body and influence the functioning of the ecosystem. Ex: Carbohydrate, proteins, lipids, humus etc.

Climatic factors having strong influence on the ecosystem.

There are the different types of abiotic Components. These are:

1. Water: Water is critical to survival. Water covers more than 70% of the earth‘s surface in one form or the other.
2. atmosphere: The atmosphere has important components like oxygen and carbon dioxide, which animals and plants breathe to live and combine to produce carbohydrates, other organic materials,
3. sunlight: is the primary source of energy. Plants require it for photosynthesis.
4. soil: It is composed of rocks as well as decomposed plants and animals.

ENERGY FLOW IN THE ECOSYSTEM

Biogeochemical Cycle

“Biogeochemical cycles mainly refer to the movement of nutrients and other elements between biotic and abiotic factors.” The term biogeochemical is derived from “bio” meaning biosphere, “geo” meaning the geological components and —chemical‖ meaning the elements that move through a cycle.

The earth obtains energy from the sun which is radiated back as heat, rest all other elements are present in a closed system

The water cycle (pg 28 table and pg 29 diagram)

The Carbon cycle:

Carbon cycle is the process where carbon compounds are interchanged among the biosphere, geosphere, hydrosphere, and atmosphere of the earth. In the carbon cycle, plants absorb carbon dioxide from the atmosphere through the photosynthesis process and convert this CO2 and water into oxygen and carbohydrates, which they need for growth. Animals breathe in this oxygen, eat the plants and use the carbon of carbohydrates to build their own tissues. These animals return carbon dioxide into the air, when they breathe and when they die, as the carbon is returned to the soil during decomposition. The carbon atoms in the soil may then be used in a new plant or small organisms. When we burn fossil fuels like oil, the carbon in the fuel
combines with atmosphere oxygen to form carbon di oxide.
Carbon returns to the atmosphere by
I) Respiration (as CO2)
II) Burning or combustion of fossil fuels
III) Decay of animal and plants body

The Oxygen cycle:

Photosynthesis: Plants, algae, and some bacteria use sunlight, carbon dioxide, and water to produce oxygen (O2) through the process of photosynthesis.
Oxygen Consumption: Organisms, including plants, animals, and microorganisms, consume oxygen through respiration to release energy from organic molecules.
Atmospheric Exchange: through the process of diffusion, allowing oxygen to be available for organisms to breathe.
Decomposition: When organic matter decays, microorganisms break down the organic compounds, consuming oxygen in the process.
Combustion: Burning of fossil fuels and biomass releases carbon dioxide and uses up oxygen as a reactant, contributing to the oxygen cycle.
Importance: Oxygen is essential for the survival of aerobic organisms, supporting cellular respiration and the functioning of various ecosystems. It plays a crucial role in maintaining life on Earth.

The Nitrogen cycle:

Nitrogen fixation: Conversion of atmospheric nitrogen (N2) into ammonia (NH3) or ammonium (NH4+) by nitrogen-fixing bacteria.
Nitrification: Conversion of ammonia into nitrite (NO2-) and then into nitrate (NO3-) by nitrifying bacteria.
Assimilation: Plants take up nitrate from the soil and incorporate it into their tissues to synthesize proteins and other nitrogen-containing compounds.
Consumption and Decomposition: Animals obtain nitrogen by consuming plants or other animals. When organisms die, decomposers break down their organic matter, releasing ammonium.
Denitrification: Certain bacteria convert nitrate back into atmospheric nitrogen (N2), completing the cycle.

The energy cycle :

Sunlight: Energy from the Sun is the primary source of energy for most ecosystems on Earth.
Photosynthesis: Green plants, algae, and some bacteria convert solar energy into chemical energy through the process of photosynthesis, capturing it in the form of glucose.
Food Chain: Energy flows through ecosystems via food chains, as organisms consume other organisms to obtain energy.
Energy Transfer: Energy is transferred from one trophic level to another as organisms are consumed. Only a fraction of energy is transferred from one level to the next, with a significant portion being lost as heat.
Heat Loss: As energy is transformed and transferred within ecosystems, heat is generated and lost to the surroundings, ultimately contributing to the overall energy balance of the Earth.
Efficiency and Conservation: Understanding the energy cycle highlights the importance of energy efficiency and conservation to minimize energy waste and reduce environmental impacts.

""Biogeochemical cycles are pathways through which various elements, such as carbon, nitrogen, phosphorus, and water, circulate in the biosphere. These cycles involve both biological and geological processes, and they

play a crucial role in maintaining the balance of essential elements necessary for life. Here are the key biogeochemical cycles:

Carbon Cycle: The carbon cycle involves the exchange of carbon dioxide (CO2) between the atmosphere, living organisms, and the ocean. It includes processes like photosynthesis, respiration, decomposition, and combustion.

Nitrogen Cycle: The nitrogen cycle is responsible for the conversion of atmospheric nitrogen gas (N2) into usable forms such as ammonia (NH3) and nitrate (NO3-). The cycle involves nitrogen fixation by bacteria, nitrification, assimilation by plants, and denitrification.

Phosphorus Cycle: The phosphorus cycle primarily involves the movement of phosphorus through rocks, soil, water, and living organisms. Weathering of rocks releases phosphorus, which is taken up by plants, passed on to consumers, and returned to the environment through decomposition.

Water Cycle: The water cycle, also known as the hydrological cycle, involves the continuous movement of water between the atmosphere, land, and bodies of water. It includes processes such as evaporation, condensation, precipitation, runoff, and transpiration from plants.

Sulfur Cycle: The sulfur cycle involves the circulation of sulfur between the atmosphere, land, and living organisms. Sulfur is released through volcanic activity, industrial processes, and decomposition. It can be transformed into various forms, including sulfates and hydrogen sulfide.

Oxygen Cycle: Although oxygen is not considered a traditional biogeochemical cycle, it is essential for many biological processes. Oxygen is produced through photosynthesis by plants and algae and consumed through respiration by organisms.

These biogeochemical cycles are interconnected and influence one another. They regulate the availability of nutrients and elements necessary for the growth and survival of organisms, maintain the Earth's climate, and contribute to the overall functioning of ecosystems. Human activities, such as burning fossil fuels and deforestation, can disrupt these cycles, leading to environmental imbalances and impacts on global climate patterns.

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Food chain is also defined as —a chain of organisms, existing in any natural community, through which energy is transferred‖.Understanding the food chain helps us know the feeding interrelationship and interaction between an organism and the ecosystem. It also enables us to know the mechanism of energy flow in an ecosystem.

Trophic Levels in a Food Chain

Trophic levels are different stages of feeding position in a food chain such as primary producers and consumers of different types.

Producers (First Trophic Level) − Producers otherwise called autotrophs prepare their food by themselves. They form the first level of every food chain. Plants and one-celled organisms, some types of bacteria, algae, etc. come under the category of Autotrophs.Virtually, almost all autotrophs use a process called photosynthesis to prepare food.

Consumers − At the second trophic level, there are consumers who depend upon others for food.

 Primary Consumers (Second Trophic Level) − Primary consumers eat the producers. They are called herbivores. Deer, turtle, and many types of birds are herbivores.

 Secondary Consumers (Third Trophic Level) − Secondary consumers based at the third trophic level eat plants and herbivores. They are both carnivores (meat eaters) and omnivores (animals that eat both animals and plants).

Tertiary Consumers (Fourth Trophic Level) − Tertiary consumers are animals eating other carnivores.like the King Cobra specialize in killing and eating snakes but all snakes are carnivores. The leopard seal eats mostly other carnivores - mainly other seals, squids, and penguins, all of which are carnivores.

Decomposers − Decomposers which don‘t always appear in the pictorial presentation of the food chain, play an important part in completing the food chain. These organisms break down dead organic material and wastes. Fungi and bacteria are the key decomposers in many ecosystems;

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Food web:

A food web is a more complex representation of feeding relationships in an ecosystem, involving interconnected food chains.

It reflects the actual interactions and interdependencies among various organisms in an ecosystem.

In a food web, organisms can have multiple feeding relationships, occupying different trophic levels.

It demonstrates the flow of energy and nutrients among different species, including the pathways of both predator-prey relationships and symbiotic interactions.

Food webs are significant tools in understanding that plants are the foundation of all ecosystem and food chains

The food web provides stability to the ecosystem.

Ecological Pyramids

Ecological Pyramid refers to a graphical (pyramidal) representation to show the number of organisms, biomass, and productivity at each trophic level. It is also known as Energy Pyramid. There are three types of pyramids. They are as follows −

Types of Ecological Pyramid

Pyramid of Energy:

Represents the flow of energy through different trophic levels.

Each bar in the pyramid represents the amount of energy available at each trophic level.

Energy is lost as heat through metabolic processes, so the energy available decreases as you move up the pyramid.

Typically, the energy pyramid is upright, with the highest energy at the bottom (producers) and the lowest at the top (top-level consumers).

Pyramid of Biomass:

Represents the total biomass (organic matter) present at each trophic level.

Biomass is a measure of the amount of living or organic material present.

Each bar in the pyramid represents the biomass of organisms at each trophic level.

Pyramid of Biomass (Upright):

Biomass decreases as you move up the pyramid due to energy loss in metabolic processes.

Producers (plants) have the highest biomass, followed by primary consumers (herbivores), secondary consumers (carnivores), and so on.

Pyramid of Biomass (Inverted):

Occurs when the biomass of producers is smaller, but their individual size is larger (e.g., a few large trees supporting a large number of smaller herbivores).

Typically found in aquatic ecosystems, where primary producers, such as phytoplankton, have smaller biomass but support larger populations of zooplankton and other consumers.

Note: The inverted pyramid of biomass is less common than the upright pyramid, as it depends on specific ecological conditions and the size differences between producers and consumers.

Pyramid of Numbers:

Represents the number of organisms at each trophic level.

Each bar in the pyramid represents the population or number of organisms at each trophic level.

It can be upright, inverted, or even shaped like a mushroom, depending on the specific ecosystem and trophic relationships.

In some cases, the pyramid of numbers may be inverted, especially in cases where the producers are larger in size, but their number is comparatively smaller

Values of an Ecosystem:

Intrinsic value: Ecosystems have inherent worth and should be protected for their own sake.

Biodiversity value: Ecosystems support a wide variety of species, contributing to the diversity of life on Earth.

Economic value: Ecosystems provide various resources and services that contribute to economic activities and human well-being.
Cultural value: Ecosystems hold cultural and spiritual significance, providing inspiration, recreation, and a sense of identity.

Services of an Ecosystem:

Provisioning services: Ecosystems provide resources like food, water, timber, fuel, and medicinal plants.
Regulating services: Ecosystems regulate processes such as climate, water purification, soil fertility, pollination, and pest control.
Cultural services: Ecosystems offer cultural, aesthetic, and recreational benefits, including spiritual value, art, tourism, and leisure activities.
Supporting services: Ecosystems provide fundamental processes like nutrient cycling, soil formation, and habitat provision that support other services.

Carrying capacity of an Ecosystem:

Carrying capacity refers to the maximum population size that an ecosystem can sustainably support.
It is determined by factors such as resource availability, environmental conditions, and interactions between species.
The carrying capacity can change over time due to natural processes or human activities.
When a population exceeds the carrying capacity, it can lead to resource depletion, habitat degradation, and population decline or collapse.
Understanding carrying capacity is crucial for sustainable resource use, conservation, and maintaining the health and productivity of ecosystems.

Characteristics of an Ecosystem:

Interdependence: The components of an ecosystem, including living organisms and their environment, are interconnected and rely on each other for survival and well-being.
Energy Flow: Ecosystems involve the flow of energy through the food chain or food web, with energy being transferred from one organism to another.
Nutrient Cycling: Ecosystems recycle and reuse nutrients through processes like decomposition and nutrient uptake by plants, ensuring the availability of essential elements.
Dynamic Nature: Ecosystems are dynamic and undergo changes over time, driven by natural disturbances, climate variations, and human activities.
Adaptation: Organisms within an ecosystem possess adaptations that help them survive and reproduce in their specific environment.
Resilience: Ecosystems have the capacity to resist or recover from disturbances, maintaining their structure and functioning.

Types of Ecosystems:

Terrestrial Ecosystems: The terrestrial ecosystem refers to the ecosystem of different land forms only. The atmosphere in the terrestrial ecosystem is quite different from the aquatic ecosystem.
The major types of ecosystems are forest, desert, rain forest, grassland, tundra, savanna and mountain ecosystem.
Aquatic Ecosystems: The ecosystem found in different water bodies is known as an aquatic ecosystem
 Marine Ecosystem
Marine ecosystem covers almost 70% of the area on Earth‘s surface, hence known as one of the biggest kinds of ecosystems on the Earth. Water is the main component of the marine ecosystem, which contains various minerals & salt dissolved in it.
 Freshwater Ecosystem
Freshwater is another type of aquatic ecosystem that covers less area as compared to the marine ecosystem. The freshwater ecosystem covers almost 0.8% of the Earth‘s surface.
Forest Ecosystems: The forest ecosystem has a huge variety of flora and fauna living together in a specific

area. There are different types of forest ecosystems based on climatic conditions such as tropical, temperate, boreal, etc. The forest ecosystem is one of the crucial terrestrial ecosystems that provide shelter to thousands of plant & animal species.

Grassland Ecosystems: the grassland ecosystem mainly contains grasses along with some species of shrubs & trees. Grassland is a perfect region for grazing animals. The atmosphere in the grassland ecosystem is quite pleasant, and the climatic conditions are very similar to semi-arid regions. The mostly found organisms in the grassland ecosystem are grazing animals, herbivorous.

Desert Ecosystems: Desert ecosystem has a high amount of flora & fauna. The desert ecosystem has covered almost 17% of the Earth‘s surface. Excessive temperature, extreme sunshine, less water available, etc. do not allow a variety of plants & animals to live in a desert ecosystem. plants like cactus are present in the desert ecosystem. These types of plants can conserve water as much as they can. In this region, we can find animals like camels, reptiles, a few insects, etc.

Bioaccumulation:

Bioaccumulation refers to the gradual buildup and concentration of substances, such as toxins or pollutants, in the tissues of living organisms over time.

It occurs when an organism takes in these substances at a faster rate than it can eliminate them.

Bioaccumulation is often a result of the organism's exposure to persistent and non-biodegradable substances that cannot be easily broken down or eliminated.

Substances can enter an organism through various routes, including ingestion, respiration, or direct contact with contaminated environments.

Bioaccumulation can have harmful effects on organisms, as high levels of accumulated toxins can lead to disruptions in physiological functions and adverse health effects.

Biomagnification:

Biomagnification is the process by which the concentration of certain substances, such as toxins or pollutants, increases at higher trophic levels in a food chain or food web.

As organisms at lower trophic levels consume food and accumulate substances, the concentration of those substances becomes more concentrated in their tissues.

When organisms at higher trophic levels consume these lower-level organisms, they take in a larger amount of the accumulated substances.

The process of biomagnification can lead to significant increases in the concentration of toxic substances at the top of the food chain, where predators or long-living species reside.

This can result in severe health effects and ecological impacts, as top predators may experience heightened exposure to these concentrated toxins.

Some examples of biomagnified substances include heavy metals like mercury and persistent organic pollutants such as DDT and PCBs.

Ecological Succession:

Ecological succession refers to the gradual and predictable process of change in the structure and composition of a community of organisms over time.

It occurs in ecosystems following a disturbance, such as a fire, flood, or the abandonment of an area.

Two main types of ecological succession are primary succession and secondary succession.

Primary succession occurs in areas where no soil or organisms exist, such as bare rock surfaces or newly formed volcanic islands.

The process starts with pioneer species, such as lichens and mosses, that can tolerate harsh conditions and initiate soil formation through their growth and decomposition.

As soil develops, more complex plant species, like grasses and shrubs, establish themselves, creating more favourable conditions for other plants to colonize.

Eventually, trees and a diverse array of plant and animal species become established, marking the climax community, which is the stable and self-sustaining endpoint of succession.

Secondary succession occurs in areas where soil remains after a disturbance, such as after a forest fire or land cleared for agriculture.
The process begins with the growth of fast-growing, opportunistic plant species, followed by the establishment of shrubs and trees.
Secondary succession generally progresses faster than primary succession, as soil and some pre-existing species provide a starting point.
Succession plays a vital role in the renewal and rejuvenation of ecosystems, allowing for the recovery of biodiversity and the restoration of ecosystem functions after disturbances.
Human activities can influence succession, either by disrupting natural successional processes or by intentionally facilitating ecosystem restoration and management.