Unit-V: ECOSYSTEM & BIODIVERSITY

Ecosystem:
Concepts – structure - Functions and types of ecosystem - Abiotic and biotic components – Energy flow and Energy dynamics of ecosystem - Food chains - Food web - Tropic levels - Biogeochemical cycles (carbon, nitrogen and phosphorus).
Biodiversity:
Definition - level and types of biodiversity concept - significance magnitude and distribution of biodiversity trends - bio geographical classification of India - biodiversity at national, global and regional level.

ECOSYSTEM

SHORT ANSWER QUESTIONS

1. ***Write about functions and types of ecosystems.***
2. ***Explain biodiversity at global level.***
3. ***Explain food chain.***
4. ***Describe Biodiversity at regional level.***
5. ***Discuss briefly about Carbon cycle.***
6. ***What are Abiotic and biotic components.***

LONG ANSWER (ESSAY TYPE) QUESTIONS

1. ***Outline the functions and types of ecosystems.***
2. ***Give a detailed account on biodiversity.***

Concept of Ecosystem:

Living organisms cannot live isolated from their non-living environment because the non-living environment provides materials and energy for the survival of the living organisms, i.e. there is interaction between a biotic community and its environment to produce a stable system.

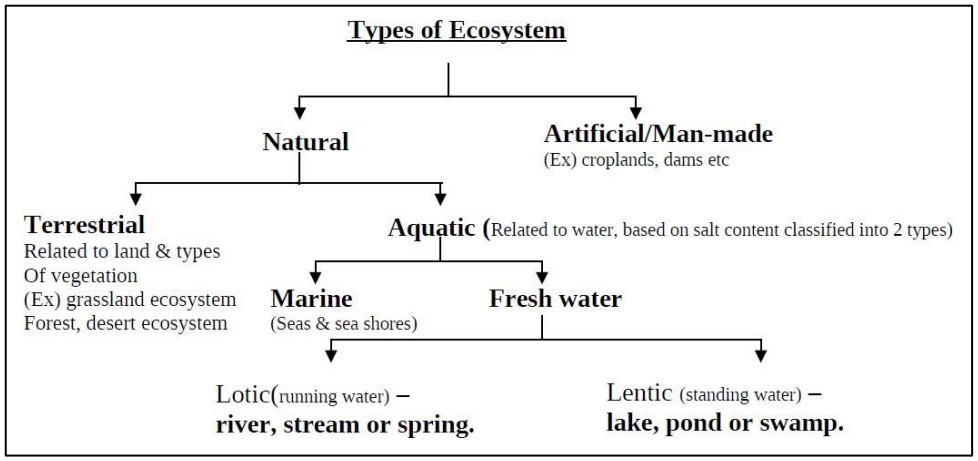
The term 'ecosystem' was coined by **A.G. Tansley**, an English botanist, in **1935**.

"An ecosystem is the structural and functional unit of ecology (nature) encompassing complex interaction between its biotic (living) and abiotic (non-living) components".

For example:

A pond is a good example of ecosystem. A pond, lake, desert, grassland, meadow, forest etc. are common examples of ecosystems.

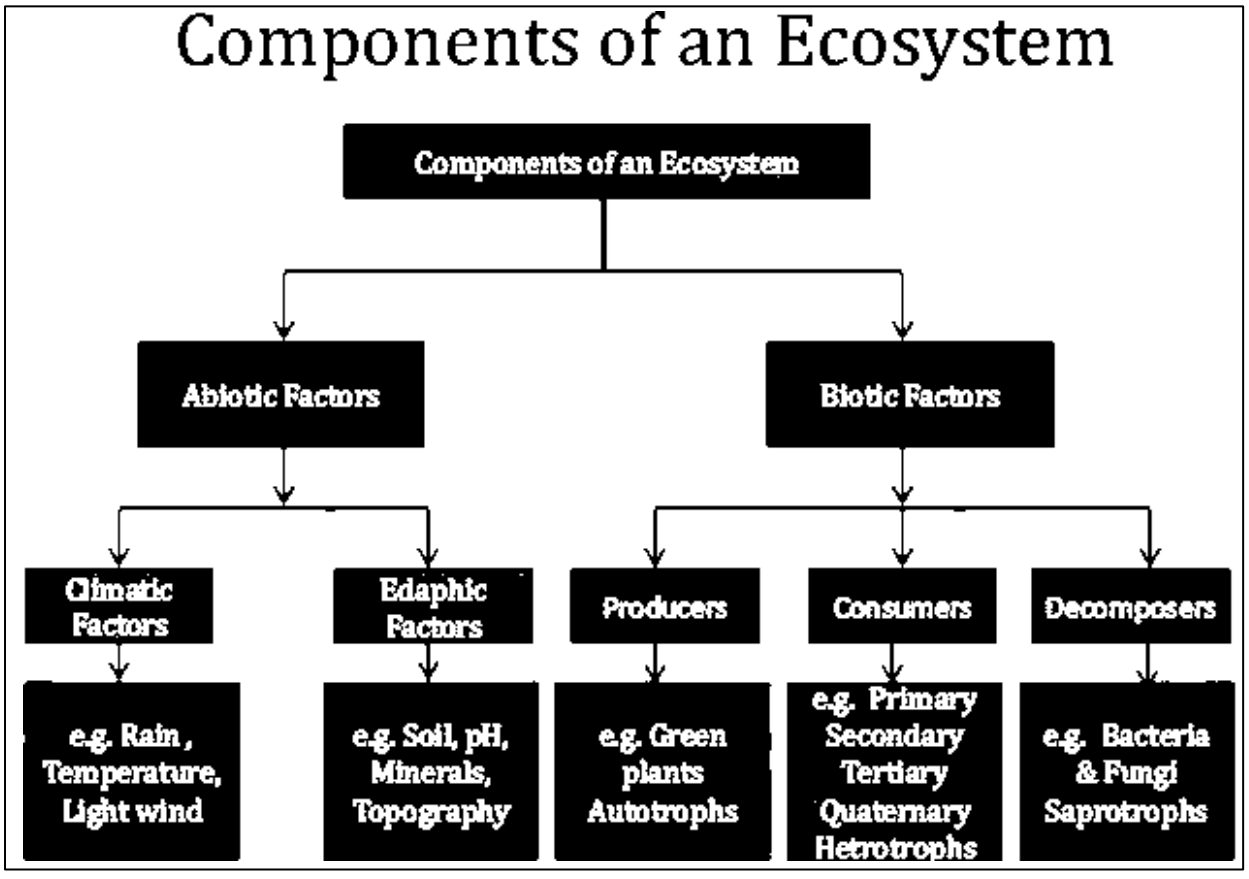
Structure and Function of an Ecosystem:



Each ecosystem has two main components:

(1) Abiotic

(2) Biotic



(1) Abiotic components (Non-living):

The abiotic component can be grouped into following categories:

(a) Climatic Factors: Which include rain, temperature, light, wind, humidity etc.

(b) Edaphic Factors: Which include soil, pH, topography minerals etc.

The functions of important factors in ***abiotic*** components are given below:

Soils:

- Soils are much more complex than simple sediments.
- Soils contain a mixture of rock fragments, different soil mineral particles, organic matter, and living organisms.
- Soils provide nutrients, water and a structural growing medium for organisms.
- The vegetation growing on top of a soil is closely linked to nutrient cycling.

The atmosphere:

- The atmosphere provides carbon dioxide to organisms found within ecosystems for photosynthesis and oxygen for respiration.
- The processes of evaporation, transpiration and precipitation in water cycle between the atmosphere and the Earth's surface.

Solar radiation:

- Solar radiation is used in ecosystems to heat the atmosphere and to evaporate and transpire water into the atmosphere.
- Sunlight is also necessary for photosynthesis. Photosynthesis provides the energy for plant growth and metabolism.

Water:

- Water is the medium by which mineral nutrients enter and are trans-located in plants.
- It is also necessary for photosynthetic chemical reactions.
- Plants and animals receive their water from the Earth's surface and soil.
- The original source of this water is precipitation from the atmosphere.

(2) Biotic components:

The living organisms including plants, animals and micro-organisms (Bacteria and Fungi) that are present in an ecosystem form the biotic components.

(A) Producers:

- The green plants have chlorophyll with the help of which they trap solar energy and change it into chemical energy of carbohydrates using simple inorganic compounds namely water and carbon dioxide. This process is known as **photosynthesis**.
- As the green plants manufacture their own food they are known as **Autotrophs** (i.e. auto = self, trophos = feeder).
- The chemical energy stored by the producers is utilised partly by the producers for their own growth and survival and the remaining is stored in the plant parts for their future use.

(B) Consumers:

- The animals lack chlorophyll and are unable to synthesise their own food. Therefore, they depend on the producers for their food. They are known as **heterotrophs** (i.e. heteros = other, trophos = feeder).

The consumers are of **four** types, namely:

(i) **Primary Consumers** or **First Order Consumers** or **Herbivores**:

These are the animals which feed on plants or the producers. They are called herbivores.

Examples: rabbit, deer, goat, cattle etc.

(ii) **Secondary Consumers** or **Second Order** Consumers or **Primary Carnivores**:

The animals which feed on the herbivores are called the primary carnivores.

Examples: cats, foxes, snakes etc.

(iii) **Tertiary Consumers** or **Third Order** Consumers:

These are the large carnivores which feed on the secondary consumers.

Example: Wolves.

(iv) **Quaternary Consumers** or **Fourth Order** Consumers or Omnivores:

These are the largest carnivores which feed on the tertiary consumers and are not eaten up by any other animal. Examples are lions and tigers.

(C) Decomposers or Reducers:

Bacteria and fungi belong to this category. They breakdown the dead organic materials of producers (plants) and consumers (animals) for their food and release to the environment. These simple substances are reused by the producers resulting in a cyclic exchange of materials between the biotic community and the abiotic environment of the ecosystem. The decomposers are known as **Saprotrophs** (i.e., sapros = rotten, trophos = feeder).

FUNCTIONS OF ECOSYSTEM:

Ecosystems are complex dynamic system. They perform certain functions. **These are:**

(i) Productivity

(ii) Decomposition

(iii) Physical (energy flow)

(iv) Biological (food chains, food web, ecological succession), and

(v) Biogeochemical (nutrient cycling) processes

(i) Productivity:

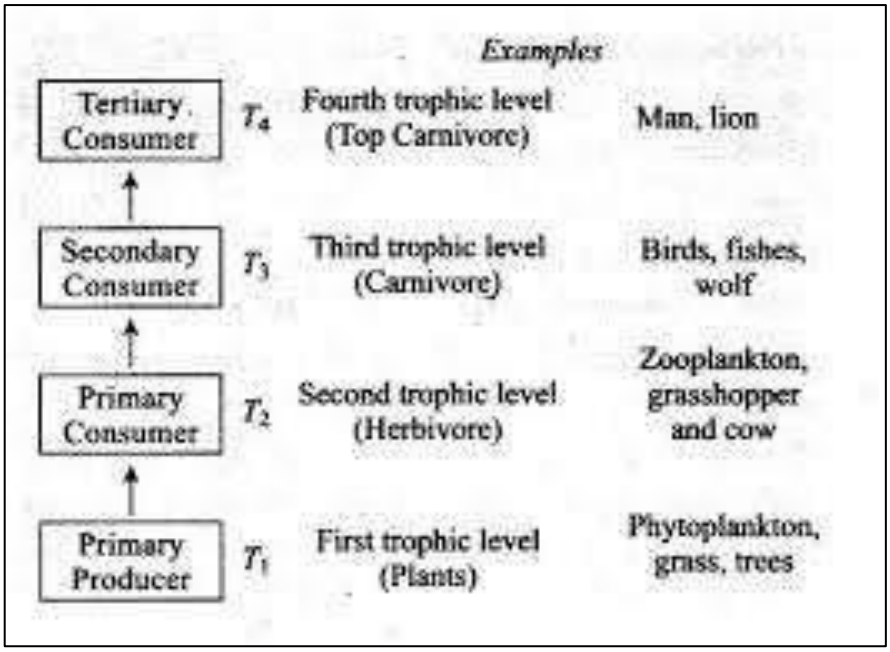
- Solar energy is the basic requirement for any ecosystem to function and sustain.
- Primary production is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. It is expressed in terms of weight (g^{-2}) or energy (kcal m^{-2}).
- Secondary productivity is defined as the rate of formation of new organic matter by consumers.
- Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, availability of nutrients and photosynthetic capacity of plants. Therefore, it varies in different types of ecosystems.

(ii) Decomposition:

- The earthworm being referred to as the farmer's 'friend'. This is so because they help in the breakdown of complex organic matter as well as in loosening of the soil.
- Similarly, decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition.
- Dead plant remains such as leaves, bark, flowers and dead remain of animals, including faecal matter, constitute detritus, which is the raw material for decomposition.
- The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation. Detritivores (e.g., earthworm) break down detritus into smaller particles. This process is called fragmentation.

(iii) Energy Flow (Physical):

- The chemical energy of food is the main source of energy required by all living organisms. This energy is transmitted to different trophic levels along the food chain. This energy flow is based on two different laws of thermodynamics:
- ***First law of thermodynamics,*** that states that energy can neither be created nor destroyed, it can only change from one form to another.
- ***Second law of thermodynamics,*** that states that as energy is transferred more and more of it is wasted. The energy flow in the ecosystem is one of the major factors that support the survival of such a great number of organisms.
- For almost all organisms on earth, the primary source of energy is solar energy.



- we receive about 40 to 50 percent of the energy having Photosynthetically Active Radiation (PAR) and only around 2-10 percent of it is used by plants for the process of photosynthesis. Thus, this percent of PAR supports the entire world as plants are the producers in the ecosystem and all the other organisms are either directly or indirectly dependent on them for their survival.

(iv) Biological (food chains, food web, ecological succession):

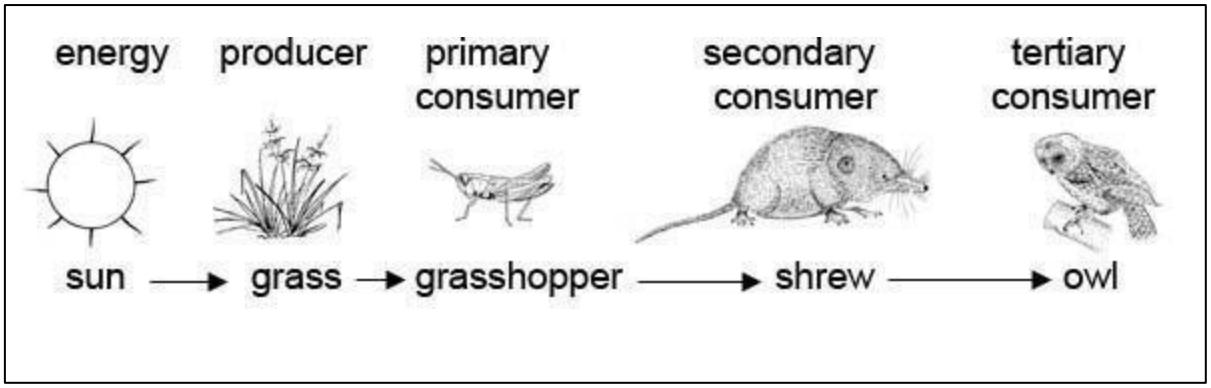
(a) Food Chain:

Definition:

The sequence of eating and being eaten in an ecosystem is called food chain

(or)

Transfer of food energy from the plants through a series of organisms is food chain.



In nature, basically two types of food chains are recognized –

(i) Grazing food chains: which starts from the green plants that make food for herbivores and herbivores in turn for the carnivores. Most of the ecosystems in nature follow this type of food chain.

A simple grazing food chain (GFC) is depicted below:

The **phytoplanktons → zooplanktons → Fish sequence**

or

the **grasses → rabbit → Fox/ Lion** sequences are the examples of grazing food chain.

(ii) Detritus food chains: start from the dead organic matter to the detritivore organisms which in turn make food for protozoan to carnivores etc. The detritus food chain (DFC) begins with dead organic matter. It is made up of

decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organic matter or detritus. These are also known as saprotrophs (sapro: to decompose).

Parasitic food chain:

Parasitic food chain is also an auxiliary food chain. It begins with the host and usually end in parasite.

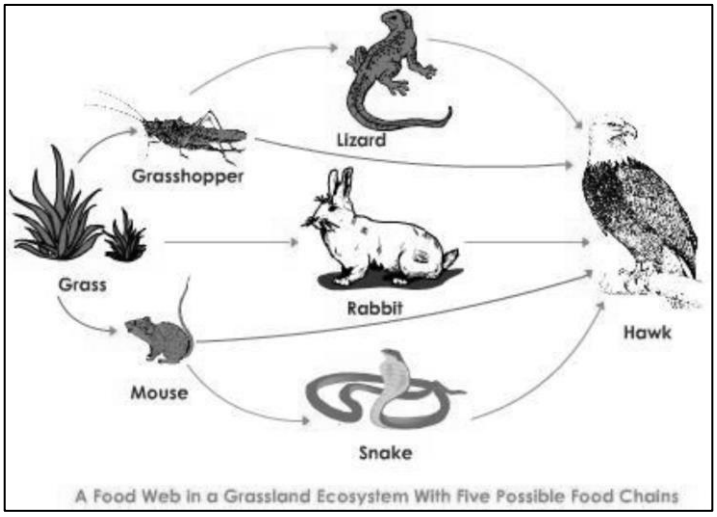
(B) Food web

"In an ecosystem, the various food chains are interconnected to each other to form a network called food web"

- A food web illustrates all possible transfers of energy and nutrient among the organisms in an ecosystem, whereas food chain traces only one pathway of food.
- Food webs are very important in maintaining the stability of an ecosystem.

Energy Flow in Food web:

- Grass → insects → fishes → birds → tigers
- Grass → insects → birds → tigers
- Grass → deer → tigers
- Grass → cattle → tigers
- Grass → rats→ snakes → eagles → tigers
- Grass → rats → eagles → tigers

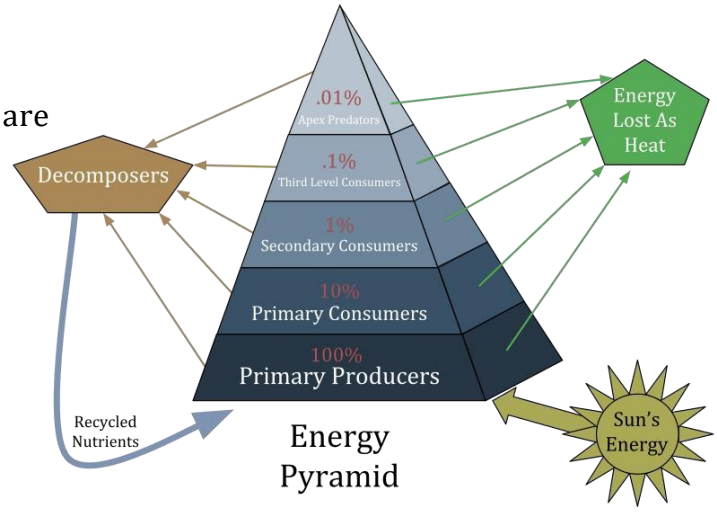


A Food Web in a Grassland Ecosystem With Five Possible Food Chains

Trophic levels:

- The trophic level of an organism is the position it occupies in a food web.
- The trophic level of an organism is the number of steps it is from the start of the food chain or food web.

Level 1:
Plants and algae make their own food and are called producers.
Level 2:
Herbivores eat plants and are called primary consumers.
Level 3:
Carnivores that eat herbivores are called secondary consumers.
Level 4:
Carnivores that eat other carnivores are called tertiary consumers.



An energy pyramid illustrates how much energy is needed (flows upward) to support the next trophic level. Only about 10% of the energy transferred between each trophic level is converted to biomass.

(v) Biogeochemical (nutrient cycling) processes:

Nutrient Cycling:

- All elements in the earth are recycled time and again.
- The major elements such as oxygen, carbon, nitrogen, phosphorous, and sulphur are essential ingredients that make up organisms.
- Biogeochemical cycles refer to the flow of such chemical elements and compounds between organisms and the physical environment.

"The cyclic exchange of material between the living organisms and their non-living environment is called Biogeochemical Cycle"

Nutrient cycles are of two types:

(a) gaseous (e.g., nitrogen, carbon cycle)

(b) sedimentary (e.g., sulphur and phosphorus cycle).

(1) Carbon Cycle:

- Carbon enters into the living world in the form of carbon dioxide through the process of photosynthesis as carbohydrates.
- These organic compounds (food) are then passed from the producers to the consumers (herbivores & carnivores).
- This carbon is finally returned to the surrounding medium by the process of respiration or decomposition of plants and animals by the decomposers.
- Carbon is also recycled during the burning of fossil fuels.

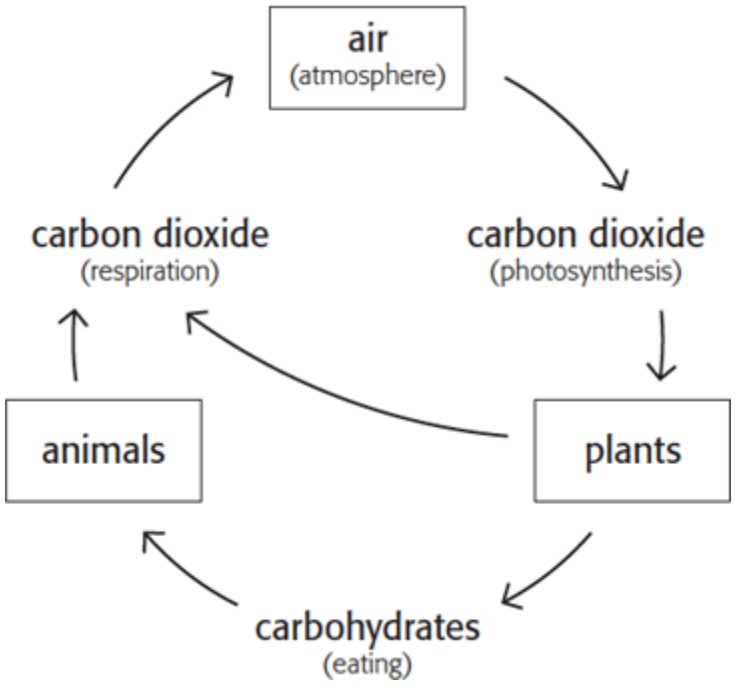


Fig: CARBON CYCLE

(2) **Nitrogen cycle:**

- Nitrogen is an essential component of protein and required by all living organisms including human beings.
- Our atmosphere contains nearly 78% of nitrogen but it cannot be used directly by the majority of living organisms.

There are five main processes which essential for nitrogen cycle are elaborated below:

(a) Nitrogen fixation:

- This process involves conversion of gaseous nitrogen into Ammonia, which can be used by plants.
- Atmospheric nitrogen can be fixed by the following three methods:

  (i) Atmospheric fixation: Lightening, combustion and volcanic activity help in the fixation of nitrogen.

  (ii) Industrial fixation: At high temperature (400^{o}C) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.

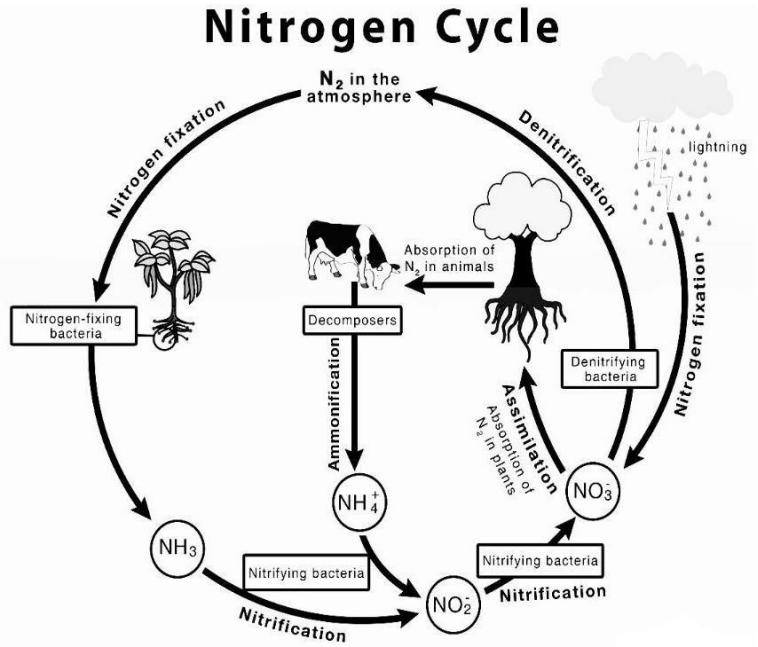
  (iii) Bacterial fixation: There are two types of bacteria-

  (i) Symbiotic bacteria, e.g. Rhizobium in the root nodules of leguminous plants.

  (ii) Free-living or symbiotic e.g. 1. Nostoc 2. Azobacter 3. Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

(b) **Nitrification**: It is a process by which ammonia is converted into nitrates or nitrites by Nitrosomonas and Nitrococcus bacteria respectively. Another soil bacteria Nitrobacter can covert nitrate into nitrite.

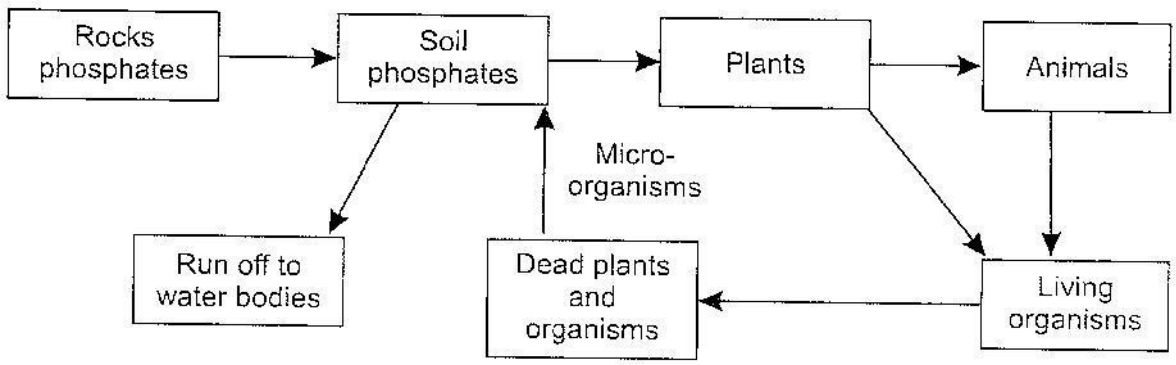
(c) Assimilation: In this process nitrogen fixed by plants is converted into organic molecules such as proteins, DNA, RNA etc. These molecules make the plant and animal tissue.



(d) Denitrification: Conversion of nitrates back into gaseous nitrogen is called denitrification. Denitrifying bacteria live deep in soil near the water table. Denitrification is reverse of nitrogen fixation.

(3) Phosphorus Cycle:

- Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems.
- Many animals also need large quantities of this element to make shells, bones and teeth.
- The natural reservoir of phosphorus is rock, which contains phosphorus in the form of phosphates. When rocks are weathered, minute amounts of these phosphates dissolve in soil and are absorbed by the roots of the plants (Fig.).
- Herbivores and other animals obtain this element from plants.
- The waste products and the dead organisms are decomposed by phosphate-solubilising bacteria releasing phosphorus.
- Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere.
- The other two major and important differences between carbon and phosphorus cycle are firstly, atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs, and, secondly, gaseous exchanges of phosphorus between organism and environment are negligible.



BIODIVERSITY

Definition:

"Biodiversity is defined as the variety and variability among all groups of living organisms and the ecosystem in which they live"

Significance of biodiversity:

1. Biodiversity protects the fresh air, clean water and productive land.
2. It is also important for forestry, fisheries and agriculture, which depend on rich water variety of various biological resources available in nature.
3. Loss of biodiversity exerts heavy economic and social costs for any country.
4. It is very important for human life; we depend on plants, microorganisms and earth's animals for our food, medicine and industrial products.

LEVELS OF BIODIVERSITY:

Biodiversity is usually considered at 3 different levels:

1. Genetic diversity
2. Species diversity
3. Ecosystem diversity

(1) Genetic diversity: Genes are the basic unit of hereditary information, transmitted from one generation to the other. Within individual species, there are a number of varieties, which are slightly different from one another. These differences are due to difference in the combination of genes.

Example: all rice varieties belong to the species "Oryza sativa"; but there are thousands of wild and cultivated varieties of rice, which shows variations at the genetic level and are different in their colour, size, shape, nutrient content of the plant.

(2) Species diversity: A discrete group of organisms of the same kinds is known as species. Species diversity is the diversity between different species. The sum of varieties of all the living organisms at the species level is known as species diversity.

Example: There are more than 20 million organisms on the earth, which have been identified and given names. Apple, mango, grapes, wheat, rice, etc. are examples of plant species.

(3) Ecosystem diversity: It is a set of biotic components [*such as plants, animals and microorganisms*] interacting with one another and with abiotic components [*such as soil, air, water, etc*.]. The diversity at the ecological or habitat level is known as "ecosystem diversity". *A large region with different ecosystems can be considered as* **ecosystem diversity**. The ecosystem also shows variation with respect to physical parameters like moisture, temperature, altitude, precipitation, etc.

Example: Forest ecosystem is supposed to have mainly dominance of trees. But, while considering a tropical rain forest, a tropical deciduous forest and a temperature forest, variations observed are numerous due to variations in the physical factors.

BIOGEOGRAPHICAL CLASSIFICATION OF INDIA:

- India is a mega diversity country having different types of climates and topography in different parts of the country. These variations have induced much variability in flora and fauna. India occupies 10^{th} position among the plant-rich countries of the world.
- It is a very important to know and study the distribution, elevation and environmental relationship of plants and animals in time and space.

Biogeography:

It comprising of photo-geography and zoo-geography, which deals with aspects of plants and animals, respectively. In order to know about the distribution and environmental interaction of flora and fauna of our country, it has been classified into 10 bio-geographical zones. Each of these zones has its own climate and soil topography (shape and features of the earth) and biodiversity.

GLOBAL BIODIVERSITY:

- Following the 1992 "**earth summit**" at Rio de Janeiro (Brazil), it became evident that there is a growing need to know about the huge number of species, which are still unknown on this earth.
- Roughly 1.5 million species are known till today, which is perhaps 15% of the actual number of the total earth-biodiversity. It has, therefore, been rightly recognized as an emergency task in order to plan its conservation and practical utilization.
- Terrestrial biodiversity of the earth is best described as "biomass", which is the largest ecological unit present in different geographic areas.

  Example: Tropical rain-forests are inhabited by millions of species of plants, birds, amphibians, insects and mammals. They are the earth's **largest** store house of biodiversity. About 50-80% of global biodiversity lies in these rain-forests.3,000 plants, identified by national cancer research institute [NCRI], are marvellous sources of cancer fighting chemicals.
- Very recently extract from one of the creeping wines in the rain forests at Cameroon has proved effective in the inhibition of replication of 'AIDS' virus.
- Tropical forests have much less biodiversity, but there is much better documentation of the species at global level, representing about 170,000 of flowering plants, 30,000 of vertebrates and about 250,000 of other groups of species.

BIOLOGICAL DIVERSITY AT NATIONAL LEVEL:

Every country is characterised by its own biodiversity depending mainly on its climate.

1. India has a rich biological diversity of flora and fauna, representing about 6% of the global biodiversity.
2. India ranks 10^{th} among the plant-rich countries of the world, 11^{th} in term of number of endemic species of high vertebrates and 6^{th} among the centres of diversity and origin of agricultural crops.

LOCAL BIODIVERSITY:

Biodiversity at regional level is better understood by categorizing species-richness into four types.

Point richness: It refers to the number of species that can be found at a single point in a given space.

1. **Alpha (α) richness:** It refers to the number of species that can be found in a small homogeneous area.
2. **Beta (β) richness:** It refers to the rate of change of species-composition across different habitats.
3. **Gamma (γ) richness:** It refers to the rate of change of species-composition across large landscape gradients.

INDIA AS A MEGA DIVERSITY NATION:

- India has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rain forests to alpine vegetation and from temperate to coastal wetlands.
- India is one of the 12 mega biodiversity countries in the world.
- In 2000, government of India recorded 47,000 species of plants and 81,000 species of animals, which is about 7% and 6.5%, of global flora and fauna, respectively.

Endemism:

Species, which are restricted only to a particular area, are known as endemic species. India shows a good number of endemic species; it is recorded that about 62% of amphibians and 50% of lizards are endemic to India.

Centre of origin:

Large number of species are known to have originated in India. India has been the centre of origin of 166 species of crop plants and 320 species of wild species or of wild relative of cultivated crops. Nearly 5,000 species of flowering plants have their origin in India.

Marine biodiversity:

- There exists a rich biodiversity along 7,500 km long coastline of our country, carrying mangroves, estuaries, coral reefs, back-water, etc.

- The marine biodiversity is rich in moleskins, crustaceans [crabs], polychquetus and corals, several species of mangrove plants and sea grasses [marine algae] are also found in our country.
- India's forest cover of 64.01 million hectares and has a rich biodiversity of plants in the Trans-Himalayan, North-West, central and Eastern Himalayan Forest, coasts, deserts, Gangetic plain, Nicobar and Lakshadweep Island.

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