

## ECOSYSTEM

### Unit - X: Ecology and Environment

#### Introduction:

- An ecosystem is a functional unit of nature, where interaction within the living and non-living components and with their surrounding physical environment occurs through energy exchange and flow of nutrients.
- It is smallest, self maintained unit of environment.
- In 1935, **A.G. Tansley** coined the term 'Ecosystem'.

#### Ecosystem-Structure and Functions:

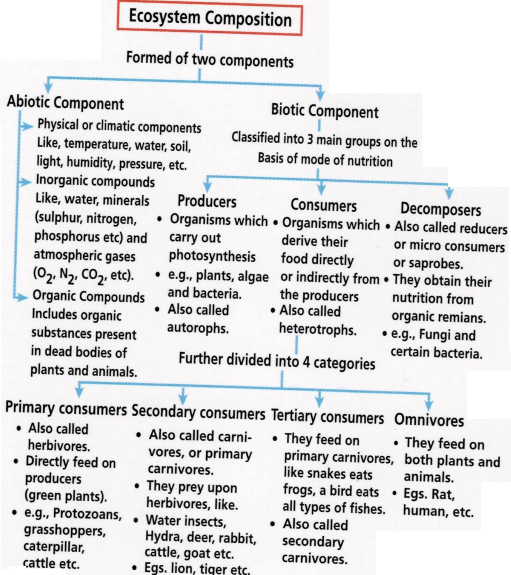
##### Types of ecosystems:

- **Natural Ecosystem** is a community of biotic and abiotic entities that occur freely in nature. It is ecosystem without Human Interference. It is further classified as, terrestrial ecosystem (e.g., forest, desert) and aquatic ecosystem (e.g., pond, lake, ocean).
- **Artificial or man-made ecosystems** are maintained and operated by human beings, e.g., crop fields, aquariums, etc.
- With **high productivity** and **less stability**.



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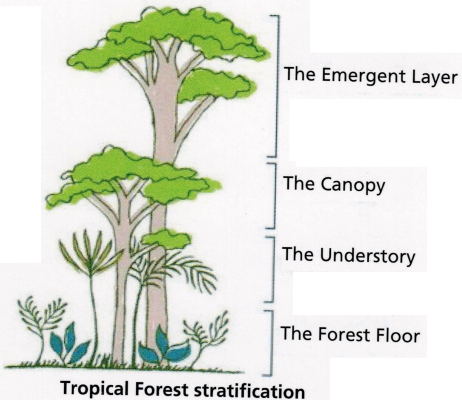
### Components of ecosystem:



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### Structure and functions of the ecosystem:

- The two important structural features of an ecosystem are:
  - **Species composition** is calculated by identification and enumeration of plant and animal species of an ecosystem.
  - **Stratification** is the vertical distribution of different species occupying different levels in an ecosystem.



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- The important functional aspects of an ecosystem are (1) productivity, (2) decomposition, (3) energy flow and (4) nutrient cycling.
- Pond ecosystem is an example that exhibits all the functional components of an ecosystem.

### Functions of Ecosystem

#### Productivity:

- It is the rate of synthesis of energy containing organic matter (biomass) by any trophic level per unit area during a given period of time. It is expressed as  $\text{gm}^{-2} \text{yr}^{-1}$  or as  $(\text{kcal m}^{-2}) \text{yr}^{-1}$ .
- **Primary productivity (Productivity of producers)** is the amount of organic matter (biomass) produced per unit area in a given time period by plants during photosynthesis. It is expressed in terms of weight ( $\text{gm}^{-2}$ ) or energy ( $\text{kcal m}^{-2}$ ). It is further of two types:
  - **Gross primary productivity (GPP)** is the rate of total production of organic matter by photosynthesis.
  - **Net primary productivity (NPP)** is the available biomass which heterotrophs can use, i.e.,  $\text{NPP} = \text{GPP} - \text{R}$  (respiratory losses).





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- Value of R = 20% → Producers
- = 30% → Primary Consumer
- = 60% → Top Consumer.
- **Secondary productivity** is the amount of new biomass produced and assimilates at any of the consumer levels in a given period of time.

### Factors affecting primary productivity:

1. Plant species
2. Climatic factors (Light, temperature, moisture, etc)
3. Nutrient availability.
4. Photosynthetic capacity of Plants.

### Energy Flow:

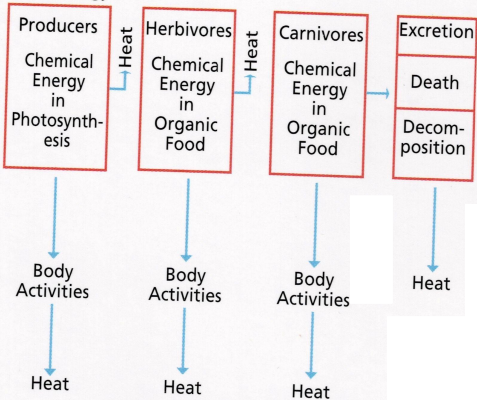
- It is the transfer of energy from one trophic level to another trophic level.
- Sun is the main source of energy. Less than 50% of incident sunlight is **Photosynthetically Active Radiation (PAR)** and out of this only 2 - 10 % is captured by plants.
- The flow of energy in an ecosystem is always **unidirectional**, i.e., it flows from the producer level to the consumer level.
- Only a small fraction of energy stored as organic compounds and transferred to consumers; the rest is used up in respiration and other life-supporting activities of the plants.



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Solar Energy



Energy Flow in an Ecosystem

- ➔ It is estimated that 90% of the energy is lost in the form of heat at each trophic level and only about 10% of the biomass energy is transferred from one trophic level to the next one in a food chain. This is called as **Ten Percent Law of Raymond Lindeman** (1942).



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### Food Chain:

→ It is the process of eating and being eaten in which energy flows from lower trophic level (producers) to higher trophic level (consumers).

There are 3 types of Food Chain:

1. Grazing Food Chain (GFC) – Aquatic ecosystem
2. Detritus Food Chain (DFC) – Terrestrial ecosystem
3. Parasitic Food Chain (PFC) – Common in both habitats.

→ It is mainly of two types, i.e., Grazing Food Chain and Detritus Food Chain.

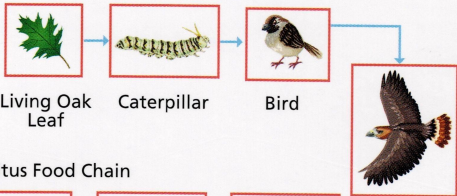
Grazing food chain	Detritus food chain
Transfer of energy starts from producers.	Transfer of energy starts from detritus/decomposing organic matter.
Less energy flows through this.	More energy flows through this.
In aquatic ecosystem, it is the major conduit for energy transfer.	In terrestrial ecosystem, it is the major conduit for energy transfer.



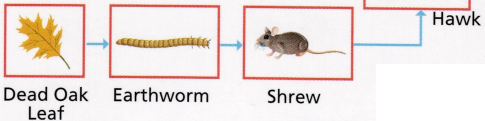
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### Grazing Food Chain



### Detritus Food Chain

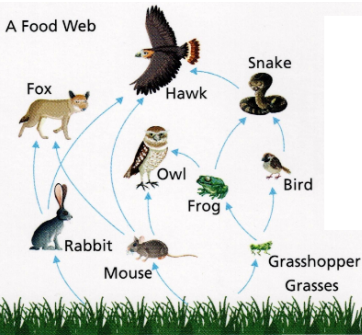


### Food Web:

- ➔ Independent food chains do not exist in nature.
- ➔ All food chains connected in a developed ecosystem at certain point.
- ➔ It is formed by the natural interconnection of food chains, where detritus food chain is connected with the grazing food chain at some levels.



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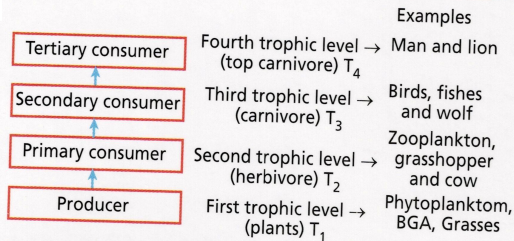
### Trophic Levels:

- It is the specific place occupied by organisms in the food chain on the basis of their feeding relationships, and on the source of their food or nutrition.



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### Diagrammatic representation of trophic levels in an ecosystem

- Each trophic level in a food chain has a certain amount of living material at a particular time, and it is called as **Standing crop**. It is measured as biomass (in terms of fresh or dry weight) or the number in a unit area.
- **Standing state** is the amount of nutrients (carbon, nitrogen, phosphorus, calcium, etc.) present in the soil at any given time. It varies in different kinds of ecosystems and also on a seasonal basis.

### Nutrient Cycling (Biogeochemical cycles):

- **Nutrient cycling** is defined as the movement of nutrient elements through the various components of an ecosystem. These cycles are of two types, **Gaseous**



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(e.g., Carbon cycle) - reservoir is atmosphere and **Sedimentary** (e.g., Phosphorous cycle) – reservoir is earth crust.

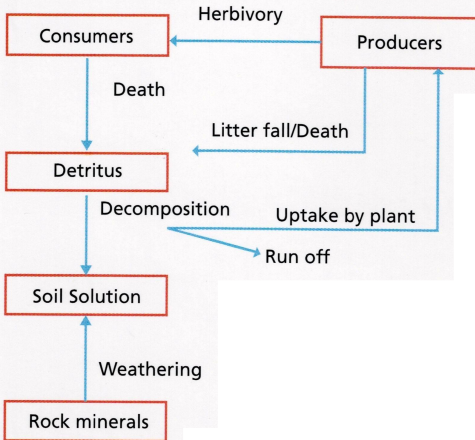
### Carbon Cycle:

- Carbon cycling occurs through atmosphere, ocean (biggest reservoir of carbon) and through living and dead organisms.
- Most of the carbon, i.e., approximately  $4 \times 10^{13}$  kg is fixed annually in the biosphere by the plants during the process of photosynthesis.
- Carbon returns to the atmosphere in the form of  $\text{CO}_2$  through respiratory activities, burning of wood, forest fire and combustion of organic matter, fossil fuel, and volcanic activity and also through decomposition process or processing of waste materials, etc.





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### Ecosystem Services:

**Concept given by Robert Costanza.**

Researchers have put an average price tag of us \$33 Trillion on these fundamental services, when the global GNP is us \$18 Trillion.

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➔ These are the products of ecosystem processes. It includes:

50% Soil formation

6% Climate Regulation

10% Recreation

10% Nutrient cycling

6% Habitat for wildlife.

Supporting services	Provisioning services	Regulating services	Cultural services
Nutrient cycling, primary production, soil formation, habitat provision and pollination maintaining balance of ecosystem.	Food, seafood, timber, skins, fuel wood, genetic resources, water, medicinal resources and ornamental resources such as furs, feathers, ivory, orchids, butterflies, etc.	Carbon sequestration, Predation regulates prey populations, Waste decomposition and detoxification, Purification of water and air, and pest control.	Cultural, spiritual and historical, recreational experiences, science and education, and Therapeutics, animal assisted therapy.





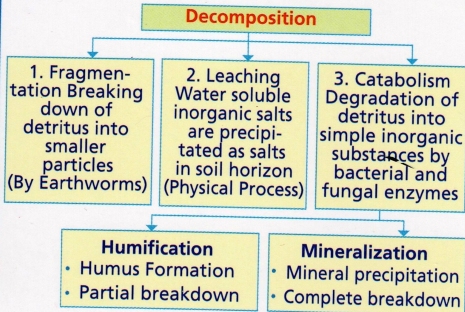
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#### Decomposition:

- It is the breakdown of complex organic material by decomposers (Fungi and Bacteria) and changing it into inorganic substances like carbon dioxide, water and nutrients.
- Detritus** (dead remain of plants and animals) is the raw material for decomposition.
- Detritivores** are the animals that feed on dead and decaying organic matter (detritus), e.g., earthworms.



#### Steps in decomposition





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- **Humus** is a dark-coloured amorphous substance which is highly resistant to microbial action and undergoes decomposition at very slow rate. Because of its colloidal nature, it serves as a reservoir of nutrients.

### Factors regulating decomposition:

- Enough oxygen availability as it is an oxygen-requiring (**aerobic**) process (Aerobiosis).

**Detritus:** — Lignin, Chitin rich → Decomposition ↓  
                  — Nitrogen, Sugar rich → Decomposition ↑

Warm and Humid = Decomposition ↑

Cold and Dry = Decomposition ↓

### Ecological Pyramids:

- It is the graphical representation of the relationship between the different living organisms at different trophic levels of food chain in terms of an ecological parameter (energy/biomass/number).
- The base of a pyramid represents producers (first trophic level). The apex represents tertiary or top-level consumer.





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### Types of pyramid

#### Pyramid of numbers

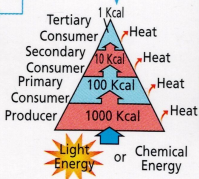
**Upright**  
In most of the ecosystem



**Spindle Shaped**  
Only in some tree ecosystem

#### Pyramid of energy

**Text Always upright (pond ecosystem)**



#### Pyramid of biomass

**Upright**  
In grassland ecosystem



**Inverted**  
In pond ecosystem





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### Exceptions to upright pyramids:

- **Inverted pyramid of number:** e.g., Insects feeding on a tree, in which the number of insects feeding on a big tree harbouring large number of parasites and thus gives an inverted shape of pyramid.
- By add an estimate of number of small birds depending on the insects, as also the number of larger birds eating the smaller, will give a spindle shaped pyramid of number.
- **Inverted pyramid of biomass:** e.g., In the sea, the pyramid of biomass is generally inverted because the biomass of fishes is far exceeds than that of phytoplanktons.

### Limitations of ecological pyramids:

- It never takes into account that the same species belonging to two or more trophic levels.
- It assumes a simple food chain that actually never exists in nature.
- It does not accommodate a food web.
- Despite performing a vital role in the ecosystem, saprophytes are not given any place in ecological pyramids.





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### Ecological Succession:

- It is the process of gradual and predictable change in the composition and structure of species that belongs to a given area. It is replacement of less adapted community by a more adapted community.
- **Pioneer species** is the species that invade a bare area.
- The entire sequence of communities that successively change in a given area is called **sere(s)** and the individual transitional communities are known as **seral stages** or **seral communities**.
- **Climax community** develops at the end of ecological succession and it is the final and stable biotic community which is almost near to equilibrium with the environment.
- During succession following events takes place:
  - Species diversity increase
  - Number of species increase
  - Total biomass increase
  - Productivity increase
  - Food chain form food web.







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- Succession is of two types:
  - **Primary succession:** It begins in an area where no living organisms ever existed. **Examples:** newly cooled lava, bare rock, newly created pond or reservoir. This process is very slow and here pioneer species are lichens, phytoplankton, etc.
  - **Secondary succession:** It begins in a habitat that has been populated in past, but have been destroyed. For instance, abandoned farm lands, burned or cut forests, lands that have been flooded. This process is comparatively faster and here pioneer species are grasses, wildflowers, algae.

### Succession of plants:

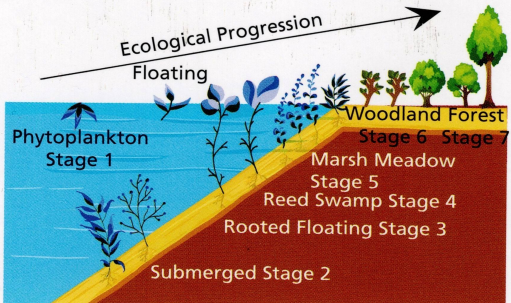
- **Hydrarch succession:** It begins in aquatic environment and the successional series progress from hydric to the mesic conditions.





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graph TD
    A[Phytoplanktons (Pioneer species)] --> B[Submerged rooted plants]
    A --> C[Floating hydrophytes]
    A --> D[Reed-swamp stage (partly submerged rooted plants)]
    B --> E[Hydrilla  
vallisneria]
    C --> F[Nymphaea,  
Azolla, Pistia]
    D --> G[Typha]
    G --> H[Marsh-meadow stage (shallow rooted vegetation)]
    H --> I[Scrub stage (terrestrial) grasses and bushes]
    I --> J[Forest stage (trees and other land plants)]
    H --> K[Cyperaceae,  
Graminae]
    I --> L[Lantana Salix]
    J --> M[Hopea  
Populus]
  
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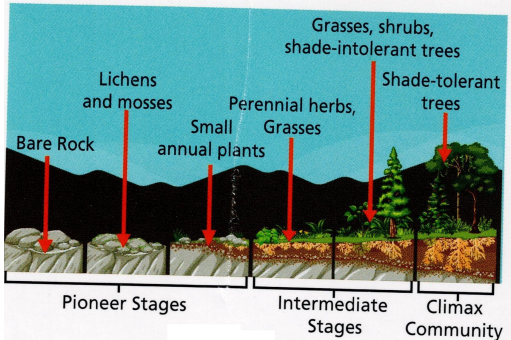




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- **Xerarch succession:** It begins in extremely dry situations and the successional series progress from xeric to mesic conditions.



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1. The rate of production of organic matter during photosynthesis in an ecosystem is termed as:
  - (a) Net productivity
  - (b) Net primary productivity
  - (c) Gross primary productivity
  - (d) Secondary productivity
2. Following are the processes that occur during decomposition. Which one of the following is correctly described?
  - (a) **Fragmentation:** Carried out by organisms such as earthworm.
  - (b) **Humification:** Leads to the accumulation of a dark coloured substance humus which undergoes microbial action at a very fast rate.
  - (c) **Catabolism:** Last step in the decomposition under fully anaerobic condition.
  - (d) **Leaching:** Water soluble inorganic nutrients rise to the top layers of soil.
3. Name the type of food chain represented below:  
dead animals → blowfly maggot → maggots → frog → snake
  - (a) Detritus food chain
  - (b) Decomposer food chain
  - (c) Predator food chain
  - (d) Grazing food chain



**ECOSYSTEM****Solutions:****1. Option (c) is correct.**

Gross primary productivity is the rate of production of total organic matter by the plants during the process of photosynthesis. Whereas, Net primary productivity is the available biomass which heterotrophs can use.

**2. Option (a) is correct.**

In decomposition, fragmentation process is carried out with the help of organisms such as earthworm (detritivores) which breaks down the complex organic matter (detritus) into smaller particles. The earthworm also helps in the loosening of soil.

**3. Option (a) is correct.**

The detritus food chain starts with the dead organic matter which is acted upon by decomposers (fungi and bacteria). The food energy from detritus is passed onto the small carnivores like maggots (larvae) and in turn to the large carnivores (frog and snake).



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4. What is the fate of energy at each successive trophic level in a food chain?
  - (a) It decreases
  - (b) It increases
  - (c) Remains constant
  - (d) None of the above
5. Name the term that is used to define the successively changing sequence of communities in a given area:
  - (a) Succession
  - (b) Sere
  - (c) Climax community
  - (d) Community
6. The second stage of hydrosere is occupied by plants like:
  - (a) *Azolla*
  - (b) *Typha*
  - (c) *Salix*
  - (d) *Vallisneria*



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### Solutions:

**4. Option (a) is correct.**

At each successive trophic level in a food chain, the level of energy decreases. It is estimated that 90% of the energy is lost as metabolic heat at each trophic level and only about 10% of the biomass energy is transferred from one trophic level to the next one in a food chain.

**5. Option (b) is correct.**

Sere is the term that is used to define the successively changing sequence of communities in a given area. It is considered as an intermediate or transitional stage occurring during ecological succession in an environment progressing towards its climax community.

**6. Option (d) is correct.**

The second stage of hydrosere is occupied by submerged rooted plants like *Vallisneria*. Whereas, *Azolla* occupied the third stage, i.e., floating hydrophyte stage. *Typha* is in fourth reed swamp stage and *Salix* comes under sixth stage, i.e., Scrub stage.



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7. Which one of the following is not a gaseous biogeochemical cycle in the ecosystem?
- (a) Carbon cycle
  - (b) Oxygen cycle
  - (c) Phosphorus cycle
  - (d) Nitrogen cycle
8. Which one of the following is not a functional unit of an ecosystem?
- (a) Stratification
  - (b) Energy flow
  - (c) Productivity
  - (d) Decomposition



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## Solutions:

**7. Option (c) is correct.**

Phosphorus cycle is a sedimentary biogeochemical cycle in the ecosystem. The natural reservoir of phosphorus is rock. On the other hand, all the carbon, oxygen and nitrogen cycle are gaseous biogeochemical cycles in which reservoir is atmosphere.

**8. Option (a) is correct.**

Stratification is a structural feature of an ecosystem. It is defined as the vertical distribution of different species occupying different levels in an ecosystem. While, the important functional aspects of an ecosystem are productivity, decomposition, energy flow and nutrient cycling.

