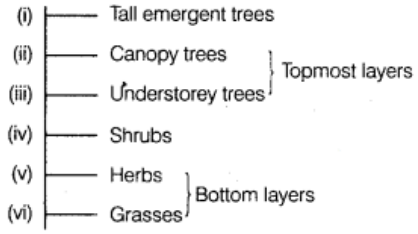
Ecosystem

Ecosystem is the functional unit of nature where living organisms interact among themselves and also with the surroundings physical environment.

Types of Ecosystem

Terrestrial	Aquatic	Man-Made (Anthropogenic)
Forest, Grassland, Desert etc	Ponds, Lake, River, Estuary, Sea etc.	Garden, Orchard, Crop Field, Aquarium, Dam etc

- Entire biosphere is regarded as Global Ecosystem.
- The biotic and abiotic factors of ecosystem work in integrated manner for flow of energy within the components of ecosystem.
- Solar Energy is the basic requirement for an ecosystem to function and sustain.
- **Stratification:** The vertical distribution of different species occupying different levels is called. For ex:
  Top vertical strata- Trees occupy
  Second layer- Shrubs
  Bottom layers- Herbs & grasses



Basic functional components of ecosystem:
(i) Productivity (ii) Decomposition (iii) Energy flow (iv) Nutrient cycling.

Pond (aquatic ecosystem) :A Shallow, simple, self sustainable water body that exhibits all basic components of ecosystem.

- Abiotic Component: Water & Soil
- Climatic Condition: Solar input, temperature, day length etc.
- Autotrophic Components: Phytoplankton's, some algae & floating, submerged & marginal plants.
- Consumers (Heterotrophs): Zooplanktons, free swimming and bottom dwelling forms.
- Decomposers: Fungi, bacteria & flagellates.

➢ Autotrophs convert inorganic material into organic using solar radiant energy.
➢ Heterotrophs consume autotrophs.
➢ Decomposition & mineralization of dead matter to release them back for reuse by autotrophs.

Productivity- The rate of biomass production.

Primary production: 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}). In a year g $^{-2}$ yr –1 or (kcal m^{-2}) yr $^{-1}$.

Type of productivity:

Gross primary productivity (GPP): The rate of production of total organic matter during photosynthesis.

Respiratory Loss (R): A considerable amount of GPP used by plant for respiration.

Net primary productivity (NPP): The remaining biomass after respiration lose (R) available for consumption to heterotrophs

Primary Productivity depends on:

- Plant species inhabiting an area.
- Environmental factors.
- Availability of nutrients.
- Photosynthetic capacity of plants

Annual net primary productivity of whole biosphere- 170 billion tons (dry weight).

Productivity of oceans (70% surface)- 55 billion tons

GPP –R = NPP

Secondary productivity : The rate of formation of new organic matter by consumers.

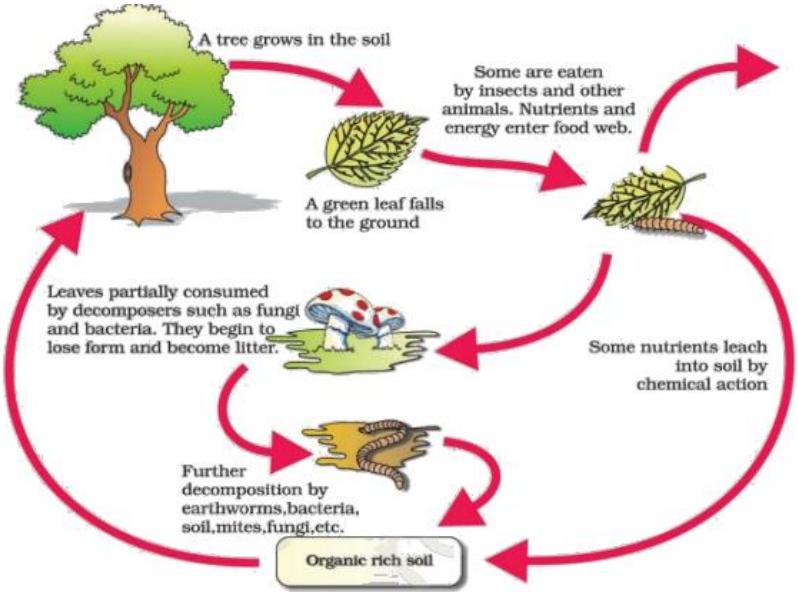
Decomposition- Breakdown of complex organic matter into inorganic substances like carbon dioxide, water and nutrients.

Detritus : It is raw material for decomposition that constitute dead plants remains like leaves, bark, flowers and dead remains of animals, faecal matter etc.

Decomposition involves following steps-

1. **Fragmentation**: Breakdown of detritus into smaller particles — increases the surface area of detritus particles for microbial action. Detritivores (earthworm) feed on detritus
2. **Leaching**: Soluble inorganic nutrients dissolve in water -– percolate through the soil —precipitate as unavailable salts.
3. **Catabolism**: Degradation of detritus into simpler inorganic compounds by enzymatic action of Decomposers (bacteria, fungi)
4. **Humification**: Simplified detritus— converted to **humus** (Dark, Amorphous substance) that is rich in nutrients being colloidal in nature, highly resistant to microbial action and undergoes decomposition very slowly.
5. **Mineralisation:** Humus is degraded by some microbes – releases inorganic substances (CO_2, H_2O etc) and nutrients (Ca^{2+}, Mg^{2+},K^+ etc)

Note: Fragmentation, leaching & catabolism occur simultaneously.



Factors affecting rate of Decomposition:

1. **Chemical composition** – Decomposition rate is slow if detritus is rich in lignin and chitin and rate increases if detritus is rich in nitrogen & water soluble substances like sugars.
2. **Climatic conditions** – warm and moist environment favour decomposition and low temperature and anaerobiosis inhibit decomposition.

Energy Flow

- All living organisms are dependent for their food on producers, directly or indirectly.
- There is a unidirectional flow of energy from the sun to producers and then to consumers.
- Sun is the only source of energy for all ecosystems (except deep sea hydrothermal ecosystem)
- Incident solar radiation, less than 50% is Photosynthetically active radiation (PAR) is responsible for synthesis of food by plants.
- Plant captures only 2-10% of PAR that sustain entire living world.
- Ecosystem obey 2nd Law of Thermodynamics. They need a constant supply of energy to synthesize the molecules. It helps to counteract the entropy.
- Animals obtain their food from plants (producers), so they are called consumers.
- No energy trapped in an organism remain in it for ever.

The sequence of eating and being eaten is called **food chain** in which energy flow from producers to consumers.

Types of food Chain: **Grazing Food Chain:** Primary Consumers feeds on producers (plants)

2 Steps Food Chain: Sugar Cane → Elephant

3 Steps Food Chain: Grass → Deer → Lion

4 Steps Food Chain: Carrot → Rabbit → Fox → Lion

5 Steps Food Chain: Grass → Grasshopper → Frog → Snake → Eagle

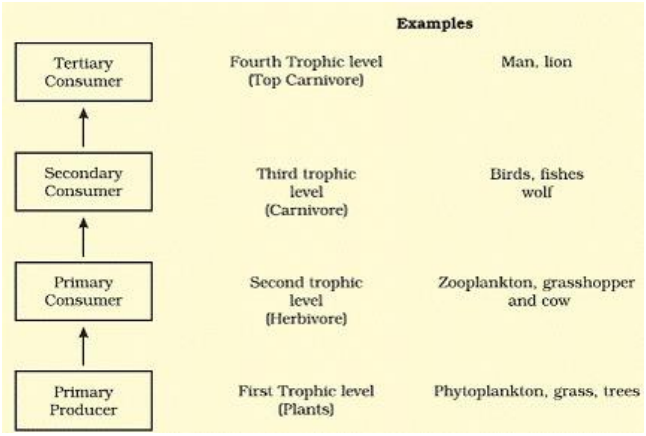
Detritus food chain (DFC): Primary consumer feeds on dead organic matter. Here primary consumers are decomposers which are heterotrophic organisms (saprotrophs - fungi and bacteria). Decomposers secrete digestive enzymes (outside the body on organic matter) that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.

ex: Dead Leaves → Wood Louse → Black Bird

Aquatic food Chain: Phytoplankton → Zooplankton → Fish

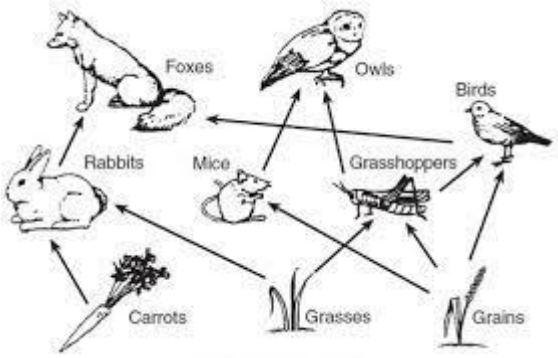
Grazing food chain	Detritus food chain
Transfer of energy starts from producers.	Transfer of energy starts from detritus/decomposing organic matter.
Less energy flows through this.	More energy flows through this.
In aquatic ecosystem, it is the major conduit for energy transfer.	In terrestrial ecosystem,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

Trophic Level: A specific place of organism in the food chain



Biomagnification: Increase in concentration of the toxicant at successive trophic levels.

Food Web: Natural interconnection of food chain forms the food web.



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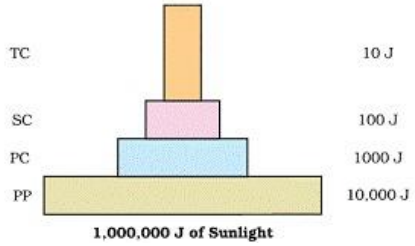
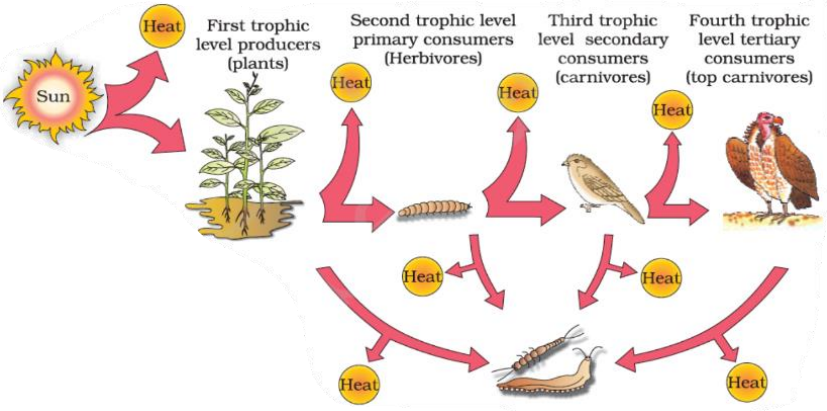
Energy Flow at Different Trophic Levels



- The amount of energy decreases at successive trophic levels.
- **10% Energy Law:** 90% of captured energy is lost as heat in the previous level and only 10% is available for the next level.
- When an organism dies, it becomes dead biomass (detritus) serve as energy source for decomposers.

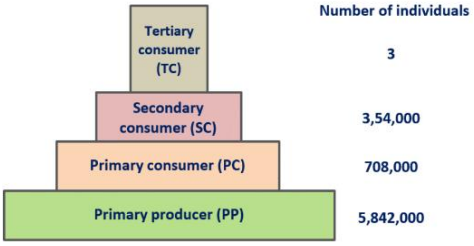


Standing crop: Each tropic level has a certain mass of living material at particular time. It is measured as biomass of living organism or number in unit area.

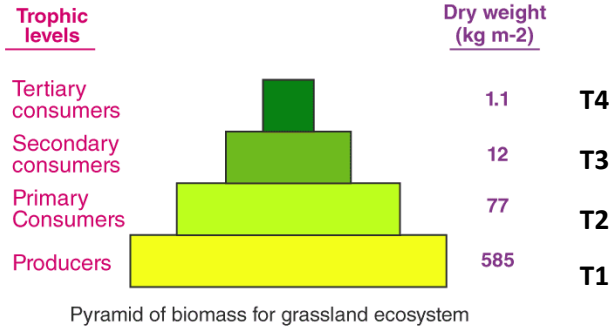
Que: Why do food chains only have 4-5 trophic levels?
Ans: The number of trophic levels in the grazing food chain is limited as the transfer of energy follows 10% energy law. The loss of energy at each step is so great that very little usable remains after four or five trophic levels

Ecological Pyramids: The graphical representation of a food chain in the form of pyramids.
It can be upright, inverted, or spindle shaped. The base of pyramid represent producers & apex level tertiary of top level consumer. Three common ecological pyramids are:

a) **Pyramids of number**- employs the number of individuals per unit area at various trophic levels with producer at base and various consumers at successively higher levels. It is generally upright.
A pyramid of number in case of a big tree is generally inverted because number of insects feeding on that tree generally exceeds in number.

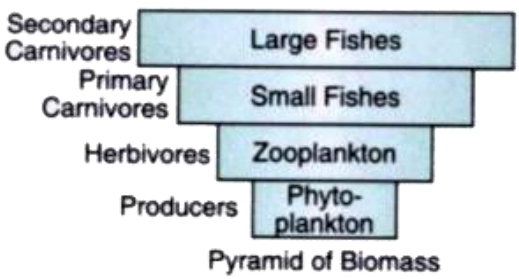


b) **Pyramids of Biomass**- represent the biomass in various trophic levels. A pyramid of mass is upright except in aquatic food chain involving short lived plankton.



Pyramid of biomass for grassland ecosystem

Inverted Pyramid



Pyramid of Biomass

c) **Pyramids of energy**- Graphic representation of amount of energy trapped by different trophic levels per unit area. **Pyramid of energy is always upright,** can never be inverted, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step e.g in feeding, digestion, assimilation and respiration.

Que: What are the limitations of ecological pyramids?

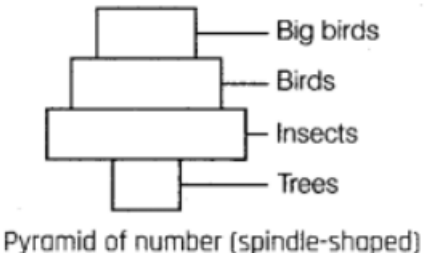
Ans: i) The decomposers which are a major part of the food chain, are not given any place in any trophic level.

ii) The organisms from the same species may be present in one or more trophic level but are considered in the same level.

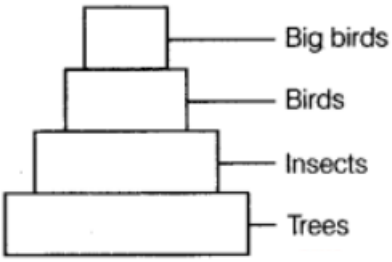
iii) The food web is not considered in the ecological pyramid but only the details of the food chain are shown.

Que: In a botanical garden of a city there is a huge banyan tree growing on which hundreds of birds and thousands of insects live. Draw the pyramids of numbers and also biomass represented by this community.

Ans:



Pyramid of number (spindle-shaped)



Pyramid of biomass