Chapter-2

Ecosystem

(Eco=Environment; System= inter-dependent complex)

Ecosystem is the basic functional unit of ecology. It consists of living organisms (biotic factors) and non-living substances (abiotic factors).

It is an interacting system where the biotic and abiotic factors interact to produce an exchange of materials between the living and non-living factors.

"The structural and functional relationship of organisms and the environment is called as ecosystem or ecological system."

At any place where the organisms live, there is continuous interaction between the living and non-living components, i.e. between plants, animals and their environment.

The function of the ecosystem is related to the flow of energy and cycling of materials through the structural components.

An ecosystem is a region with specific and recognizable area such as forest, grassland, desert, wetland etc. The nature of ecosystem is based on geographical features such as mountains, hills, plains, rivers, lake or islands. The ecosystem is also controlled by sunlight, temperature and rainfall in the area.

In the ecosystem, plants and animals live in communities. They show interaction with their non-living environment.

Structure and Composition:

The structure of any ecosystem is formed of two components:

1) Abiotic factors and
2) Biotic factors

1) Abiotic Factors: They include the non-living substances of the environment.

e.g., Water, soil, air, light, temperature, minerals, climate, pressure etc.

For the survival of biotic factors, abiotic factors are essential.

The abiotic factors are composed of- Material and Energy.

a) Materials: It constitutes water, minerals, salts and gases. These materials are continuously cycled. They enter into the living system till death and then decay & returned into soil and environment. This process is called biogeochemical cycle.

b) Energy: it includes the light and heat. In an ecosystem energy source is the sun. The plants take energy in the form of light and by photosynthesis, they convert it into food. This energy is utilized by animals in the form of food.

Abiotic components also include- inorganic substances, organic substances and climate.

a) Inorganic substances: It includes water, minerals like phosphate, carbon and gases like CO_2, N etc. These are taken up by the plants and transferred to the consumers.

b) Organic substances: They include amino acids, proteins, lipids and carbohydrates. They are synthesized by flora and fauna of an ecosystem.

c) **Climate:** it includes heat, light, rain, wind, dust, fire, storm etc.

2) **Biotic factors:** They include living organisms of the environment. E.g. plants, animals, bacteria, viruses etc. The biotic factors depend on the abiotic factors for their survival.
Biotic components are divided into 3 main groups-Producers, consumers and decomposers.

a) **Producers:** It includes autotrophic organisms i.e. green plants, algae and bacteria.
They can synthesize their own food material from simple inorganic substances in the presence of sunlight. They contain chlorophyll which is used for synthesis of food material. This process is called photosynthesis.
The producers depend on the abiotic factors for producing energy.

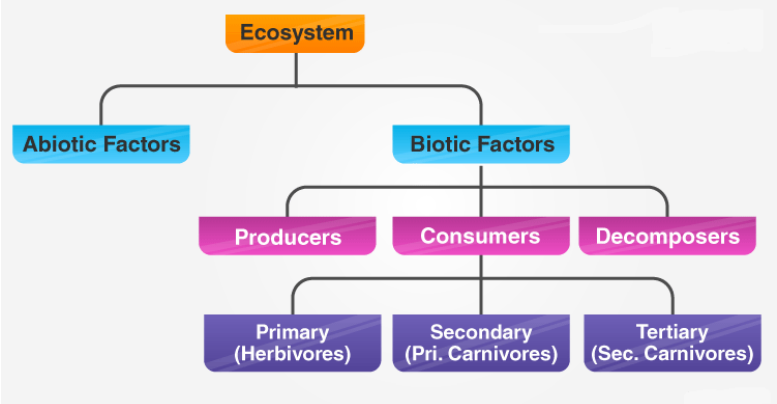
b) **Consumers:** It includes heterotrophic organisms. E.g. All animals.
All organisms that do not make their own food but depend on other organisms to obtain energy are called heterotrophs or consumers.
The consumers are divided into 3 types- Primary consumers, secondary consumers and tertiary consumers.

i) **Primary Consumers:** (Herbivores)
They eat the producers like plants, algae and bacteria. The primary consumers are also called as herbivores. E.g. Insects, cow, rabbit, deer, goat etc. in a terrestrial ecosystem.

ii) **Secondary Consumers:** (Carnivores)
They eat the herbivorous animals and also called as carnivores. E.g. Frog--- eats grasshopper.
Fox, Wolf etc. are secondary consumers in a terrestrial ecosystem.

iii) **Tertiary Consumers:**
The organisms which eat the secondary consumers are called tertiary consumers. The secondary and tertiary consumers are carnivores.
e.g. Lion, tiger, Vulture etc.

c) **Decomposers/ Reducers:** These are heterotrophic organisms which breakdown dead and waste matter. They include fungi and certain bacteria which are responsible for the decomposition.
They secrete enzymes which digest the dead bodies and debris into smaller molecules. These molecules are absorbed by the decomposers. After taking energy, they release molecules to the environment, which are again used by the producers. The role of decomposers is very special and important.



Types of Ecosystems

The ecosystem may be large as the world or small as a cow dung ecosystem. The biosphere is the major ecosystem. It includes all other ecosystems.

1) **Mega Ecosystems:** The biosphere is formed of 4 mega ecosystems-
   a) **Marine ecosystem:** It includes saline water ecosystems. E.g. Oceans, seas, estuaries etc.
   b) **Limnic ecosystem:** It includes all freshwater ecosystems. E.g. Ponds, pools, lakes, rivers, streams etc.
   c) **Terrestrial ecosystem:** It includes all ecosystems of air, forests, grasslands, deserts etc.
   d) **Artificial ecosystem:** It includes all manmade ecosystems. E.g. Cropland, city, town etc.
2) **Macro Ecosystems:** The mega ecosystem is further divided into macro ecosystems. E.g. Forests, the terrestrial macro ecosystem is formed of many forest ecosystems.
3) **Meso Ecosystems:** The macro ecosystem is further divided into meso ecosystems. E.g. The forest ecosystem is formed of many meso ecosystems like deciduous forest, coniferous forest etc.
4) **Micro Ecosystems:** The meso ecosystem is further divided into micro ecosystems. E.g. A low land in a forest, a mountain in a forest etc.

All ecosystems in the world are further divided into two types: Natural ecosystems and Artificial ecosystems.

I) **Natural Ecosystems:** These are self-regulating systems with much direct human interference and manipulations. E.g. Ponds, lakes, rivers, seas, oceans, forests, grasslands, deserts etc.

II) **Artificial Ecosystems:** These are man-made ecosystems. E.g. Croplands, cities, towns, villages etc.

❖ **<u>Natural ecosystems are again divided into two types</u>**:

I. Aquatic Ecosystems &
II. Terrestrial Ecosystems

I] Aquatic Ecosystems:

Aquatic ecosystems contain excess of water. Water covers about 3 quarters of the earth's surface either as ocean or as freshwater. Aquatic ecosystems are the source of life on earth. It contains both the aspects of ecosystem i.e., living and non-living.

Aquatic ecosystems are classified into-

1. Freshwater ecosystems
2. Marine ecosystems
3. Estuarine ecosystems

1) Freshwater ecosystems:

Freshwater ecosystems include lakes, ponds, rivers, streams, springs and wetlands. They can be classified by different factors like- temperature, light penetration, nutrients and vegetation.

Freshwater ecosystem is divided into **Lentic** (Still water) and **Lotic** (Flowing water) ecosystems.

e.g. Pond ecosystem, river ecosystem, stream ecosystem.

❖ **Pond Ecosystem:**

Pond is a suitable example for aquatic ecosystem. It is lentic (standing) freshwater ecosystem. It contains shallow standing water. The pond ecosystem is formed of abiotic factors and biotic factors.

1) Abiotic factors: The abiotic factors are water, CO_2, O_2, inorganic compounds, light, temperature, pressure, P^H etc.

2) Biotic factors: These includes plants, animals and microorganisms. They are producers, consumers and decomposers.

i. Producers: They synthesize the food from abiotic substances by photosynthesis.

The producers of pond include phytoplanktons like diatoms, blue green algae, green algae, green flagellates like volvox, euglena, Chlamydomonas etc. It also includes rooted plants, submerged plants and floating plants.

ii. Consumers: They eat other organism. The organisms which depends on producers are called primary consumers or herbivores. E.g Zooplanktons (Cyclops, daphnia, Chironomus larvae etc.), aquatic insects, snails etc.

The primary consumers are eaten by the secondary consumers or carnivores. These carnivores are called primary carnivores. E.g. small fishes, frogs, crabs etc.

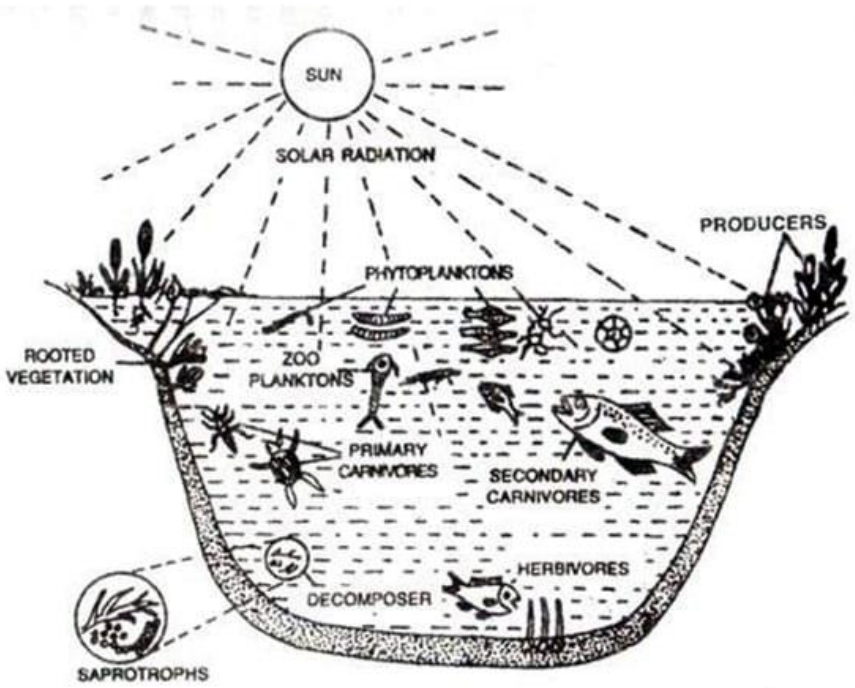
The secondary consumers are eaten by the tertiary consumers or secondary carnivores. E.g. large fishes, snakes, aquatic birds etc.

iii. Decomposers: (Reducers)

These are the organisms that breakdown the dead bodies of other organisms and their waste products. They include microbes like bacteria and fungi. They secrete enzymes.

The enzyme digests the dead organisms and debris into smaller molecules. These molecules are absorbed by the decomposers.

After taking energy, they release the molecules to the environment which are used again by the producers.



2) Marine Ecosystem:

Marine ecosystem includes the sea and oceans. It is a mega ecosystem (large).

e.g. Atlantic ocean, Pacific ocean, Arabian sea, Indian ocean, Bay of Bengal etc.

It is the largest ecosystem in the world and it occupies 70% of earth's surface. It consists of salty water. The salt content of marine ecosystem is 3.2% i.e. 3.2 parts of salts for 100 parts of water. Marine ecosystem has a wealth of aqua food. In coastal area sea is shallow and further it is deep and both shows different ecosystems.

The marine ecosystem consists of- Abiotic factors and Biotic factors.

1) **Abiotic factors:** These are non-living substances which include sea water, bottom mud, temperature, light etc.
2) **Biotic factors:** These are living organisms present in marine water.
   They include- producers, consumers and decomposers.

a) **Producers:** These are diatoms, dinoflagellates, phytoplanktons, microscopic and unicellular algae, sea weeds, brown and red algae etc. The producers are the basis of all other life in the sea. These are present upto the depth where light penetrates.

b) **Consumers:** The marine animals forms the consumers. They eat the producers and other animals. The primary consumers (Herbivores) are crustaceans, molluscs. Herbivorous fishes etc.

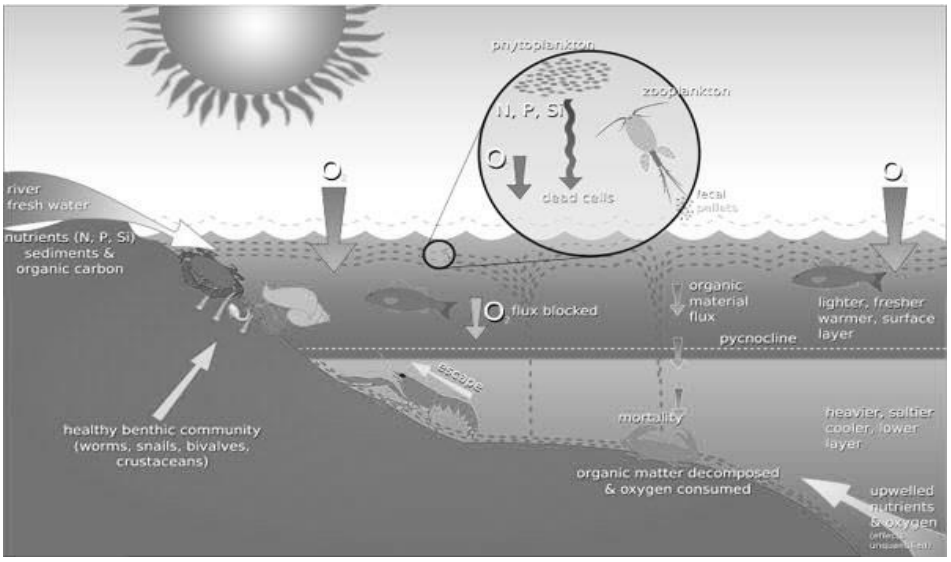
   The secondary consumers (Primary carnivores) are some large sized fishes like mackerel, herring, sharks, rays etc.

   The tertiary consumers (Secondary carnivores) are large fishes such as cods, halibuts, sharks, whales etc.

   There are many bottom feeders preying on worms, molluscs, crabs and other benthic animals.

c) **Decomposers:** Decomposers break the dead bodies of plants and animals into organic & inorganic substances. The decomposers of sea are marine bacteria. They decompose the excreta of living organisms and dead bodies of animals & plants.

In the marine ecosystem, the minerals and nutrients enter the body of producers. From producers, they enter the body of consumers. When producers and consumers die, the minerals again reach the sea.



3) Estuarine Ecosystem:

Estuary is the meeting place of river with the sea. It is a shallow water body where river water mixes with the sea water. It is an ecotone. It is the transitional zone between the river and the sea. It is an aquatic ecosystem. It is a salt water body with rich nutrient content. Estuary is an aquatic but coastal ecosystem as it is located on the sea coast.

It consists of- Abiotic and biotic components.

1) **Abiotic Components:** These are non-living substances. e.g. Water, mud, salinity, temperature, light etc.
2) **Biotic Components:** These are the living things.
   They are of 3 types- Producers, consumers and decomposers.

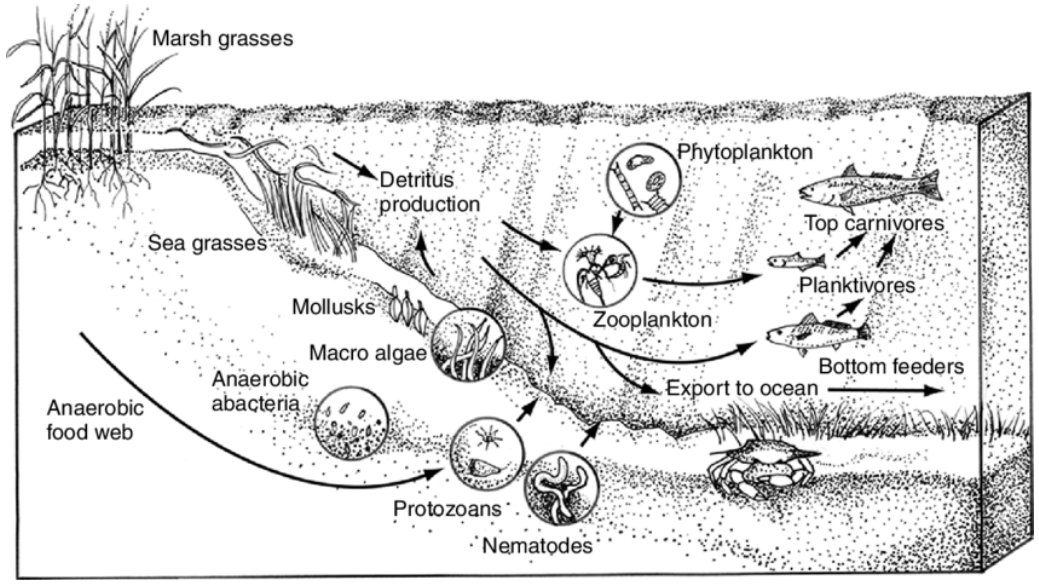
a) **Producers:** They include phytoplanktons and algae. They synthesize food using sunlight and nutrients.

b) **Consumers:** They include animals of the estuary. They eat plants and other animals.
   The consumers eating plants are called herbivores. E.g. Zooplanktons.
   The consumers eating animals are called carnivores. E.g. Fishes.
   The consumers may be primary, secondary and tertiary consumers.

c) **Decomposers:** The decomposers break the dead bodies of plants and animals e.g. Bacteria, fungi etc.

In an estuary, one member eats the other member. The chain of eating one another is called food chain. Energy flows through the food chain.

The minerals and nutrients present in the estuary are utilized by the plants. The minerals reach the animals when they eat the producers. When the plants and animals die, the dead bodies are decomposed by bacteria into nutrients which are used again by plants. This cycling of materials between the abiotic and biotic factors is called biogeochemical cycle.



II] Terrestrial Ecosystems:

It includes the ecosystems of air, forests, grasslands, deserts etc. Terrestrial ecosystems operates on the land and divided into following types-

A. Forest ecosystem
B. Grassland ecosystem
C. Desert ecosystem

A] Forest Ecosystem:

Forests are formed by a community of plants which include trees, shrubs, grasses, climbers and ground covers. Some forests are homogenous in which majority of plants are of same kind. Some forests are heterogenous which contains plants of different species.

Forests occupy roughly 40% of the total land. In India about 24% of the land is under Forests.

Forest is an ecological unit. It is a terrestrial ecosystem. It is a biome. A biome is a large land community formed of distinct plants, animals and climate.

The Forests are of three types:

1. **Rain Forests:** These are evergreen forests. The trees have broad leaves. They occur in areas of high rainfall. E.g. Forests of Western Ghats.
2. **Deciduous Forests:** These forests occur in moderate rainfall areas. The trees have broad leaves. They shed leaves during winter season.
3. **Coniferous Forests:** They contain needle like leaves. They occur in low rainfall areas. They are also called as Alpine forests or Taiga. They have cones instead of seeds (gymnosperms).

A forest ecosystem consists of 2 components:

1) Abiotic components (Non-living things)
2) Biotic components (Living things)

1) Abiotic components: They include non-living substances such as soil, water, air, sunlight, temperature etc. The forest floor is rich in dead and decaying organic matter.

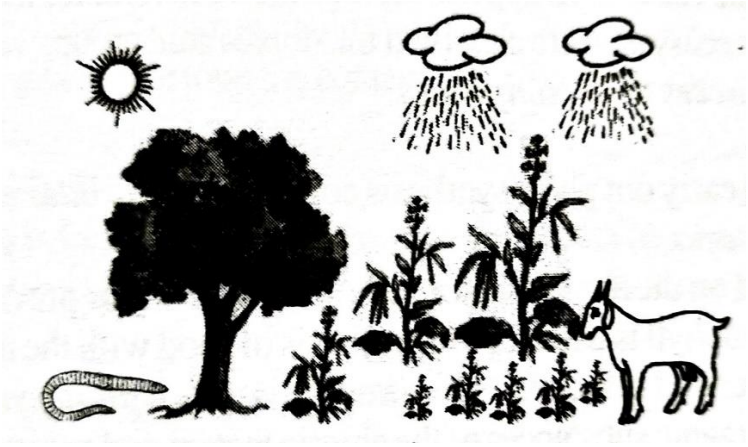


Fig. A forest ecosystem.

2) Biotic components: They include plants and animals.

The biotic components are of three types- producers, consumers & decomposers.

a) **Producers:** The producers are green plants. They synthesize food by photosynthesis. They are autotrophs. They use inorganic substances and sunlight. In forest ecosystem the producers form three major functions-

i) They provide the initial source of food.
ii) Large plants provide habitats for other organisms.
iii) They are prime agents in soil formation & in modifying the abiotic environment.

b) **Consumers:** They include animals. They eat plants and other animals.
The consumers may be- Primary consumers, secondary consumers, tertiary consumers and so on.
Primary consumers: These are the herbivores that include small arthropods such as ants, flies, beetles, leaf-hoppers, bugs, spiders etc. and large grazing animals like elephants, nilgai, wild buffaloes, deer, moles, squirrels etc.
Secondary consumers**:** These are the carnivores like snakes, birds, lizards, foxes etc. They feed upon the herbivores.
Tertiary consumers: These include the top carnivores like lion, tiger, leopard etc. which feed upon both herbivores and carnivores of secondary consumer level.

c) **Decomposers:** They break the dead bodies of producers and consumers and convert them into inorganic substances. E.g. bacteria and fungi.
Bacteria- Bacillus, clostridium, Pseudomonas etc.
Fungi- Aspergillus, Mucor, Rhizopus, Penicillium etc.
These organisms obtain energy by breaking down the organic compounds of dead organic matter.

In a forest one member eat the other. This chain of eating one another is called food chain. In ecosystem, energy flows through the food chain. E.g. when a deer eats a plant, the energy stored in the plant enter the body of the deer.

B] Grassland Ecosystem: (Prairies, Pampas)

Grassland is a herbaceous vegetation dominated by grasses. It is a terrestrial ecosystem. Grasslands occupy about 19% of the earth's surface.

Grassland cover areas where rainfall is low. The growth of trees and shrubs is prevented, but it supports the growth of grass during monsoon.

The grasses of the grasslands can be divided into two groups-

i. Tall grasses- more than 1 m. high
ii. Short grasses- less than 1 m. high

The grassland ecosystem is made up of two components: Abiotic and biotic components.

1) **Abiotic Components:** They include non-living substances such as soil, water, light, temperature etc.
2) **Biotic Components:** They include plants and animals. (Living organisms)
The biotic components are of three types- Producers, consumers and decomposers.

a) **Producers:** plants are the producers in grasslands. These are mainly grasses with herbs, shrubs and scattered trees. They synthesis food by the photosynthesis.

b) **Consumers:** the consumers are the animals. The consumers eating grass are called primary consumers or herbivores. E.g. Cows, sheep, deer, rabbit, buffaloes, bison, wild horse etc.

some insects are also primary consumers. E.g. Termites, locusts, bees, bumble bees, wasps etc.

The consumers eating the herbivores are called secondary consumers or carnivores. E.g. Fox, jackals, snakes, frogs, lizards, birds etc.

The consumers eating the secondary consumers are called tertiary consumers. E.g. Hawks, eagles etc.

c) Decomposers: These include bacteria and fungi. They break the dead bodies of plants & animals and bring the minerals back to the soil.
e.g. Mucor, Penicillium, Aspergillus Rhizopus etc.

C] Desert Ecosystem:

The deserts occupy 17% of the land and occur in the regions with average rainfall of less than 23 cm. In deserts temperature is very high, air movements and storms are common. It is a terrestrial ecosystem.

There are three major types of deserts in world-

1. Tropical deserts- Sahara, Namibia (Africa), Thar (Rajasthan), Arabian desert.
2. Temperate deserts- American desert of California, Arizona, Mexico etc.
3. Cold deserts- Gobi (Mongolia), Tibetan desert, Ladakh (Himalaya)

A desert ecosystem is made up of two components- Abiotic factors and biotic factors.

1) Abiotic factors: They include non-living substances such as sand, water, air, light, temperature etc.

2) Biotic Factors: They include living organisms such as plants and animals.
They are of 3 types: Producers, consumers and decomposers.

a) Producers: The shrubs, bushes, grasses and very few trees are the producers in deserts. The shrubs have extensive and branched root system with the stems and leaves variously modified. Succulent cacti are also found in deserts. They store water in their stem which they use during water scarcity. Some lower plants like lichens, xerophytic mosses are also found.

b) Consumers: These include animals which feed on plants and other animals. Only few animals found in deserts. E.g. Camel, kangaroo, rat, antelope, owls, hawks, uromastix, rattle snake, insects, spiders etc.

The most common animals are reptiles, insects and burrowing rodents. All these animals show morphological and physiological adaptations for deserts. Most of them are nocturnal.

Kangaroo rat and pocket mouse live without drinking water. The Camel, called as ship of desert- feeds on tender shoots of plants, store water in the body & remain without water for long periods.

Tortoise & sand snakes are common in deserts. The larger animals including carnivores are scarce.

c) Decomposers: They are thermophilic fungi and bacteria. Due to hot and cold climatic conditions the process of decomposition is very less. Due to poor vegetation and less amount of dead organic matter, the decomposers are few. The decomposers break the dead bodies of plants and animals.

FOOD CHAIN

In an ecosystem, various living organisms such as plants and animals are arranged in a definite sequence according to their food habits.

Plants are the producers which are eaten by herbivores. The herbivores are consumed by carnivores. This transfer of food energy from producers through a series of organisms (Herbivores to carnivores and to decomposers) is known as the **food chain**.

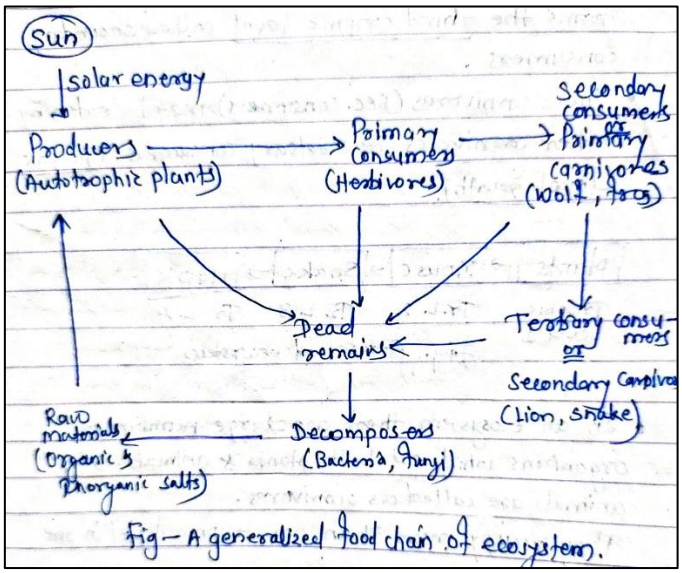


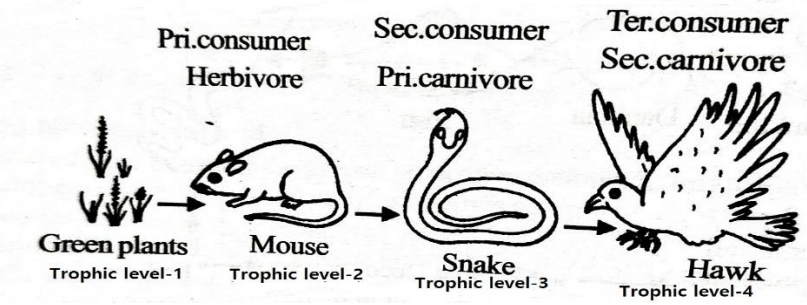
Fig – A generalized food chain of ecosystem.

The different organisms of an ecosystem are linked together by their nutritional requirements. The individuals related in this manner forms a food chain.

"A group of organisms in which there is a transfer of food energy through a series of repeated eating and being eaten is called as food chain."

The various steps in a food chain are called **trophic levels**.

- Plants converts solar energy into chemical energy (i.e., Carbohydrates) by photosynthesis.
- The producers always remain at the first trophic level in any ecosystem.
- The food energy stored in the body of plants is utilized by herbivores or plant eaters. Thus herbivores forms second trophic level called primary consumers.
- The herbivores are eaten by carnivores which forms the third trophic level called secondary consumers.
- These carnivores (Secondary consumers) may be eaten by other carnivores which forms fourth trophic level i.e. tertiary consumers.



- In an ecosystem, there are large number of organisms which eat both plants and animals. Such animals are called as omnivores. They occupy more than one trophic level in the food chain.
  e.g. Plants are eaten by insects, which are eaten by frogs, which in turn eaten by fish, which are ultimately eaten by human beings. In this food chain, there are five trophic levels. Several factors are important in determining an animal's position in a food chain. Each species occupies a specific place and participates in the flow of energy in the ecosystem.

  An animal may be a primary consumer in one chain (animals eating plants) but a secondary or tertiary consumer in other chains (animals eating herbivorous animals or other carnivores).

In nature, there are three types of food chains:

1. Grazing food chain
2. Parasitic food chain
3. Detritus food chain

1. Grazing food chain:

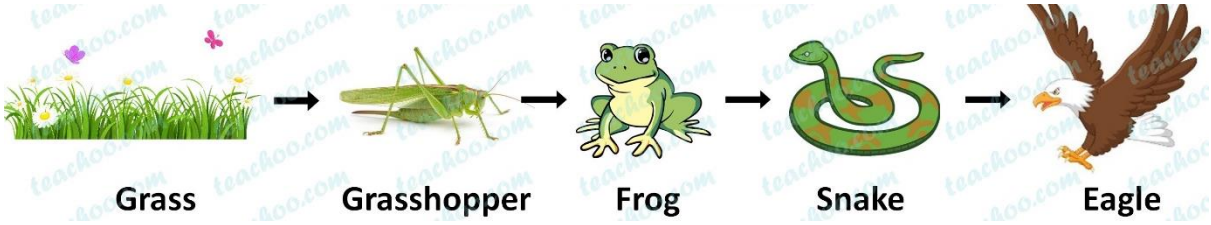
The grazing food chain starts from green plants, goes through herbivores and ends in carnivores.

Plants ⟶ Herbivores ⟶ Primary Consumers ⟶ Secondary Consumers

This type of food chain depends on the autotrophs which capture energy from solar radiation.

e.g. Grass ⟶ Grasshopper ⟶ Frog ⟶ Bird

Grass ⟶ Mouse ⟶ Snake ⟶ Hawk



2. Parasitic food chain:

It also starts from green plant base, and then moves to herbivores. These plants and animals are infected by parasites. The parasite derives their energy from their hosts. Thus, the parasitic food chain is formed within the grazing food chain.

In this food chain, the food energy passes from larger to smaller organisms. The large animals are the host and small animals act as parasites.

e.g. The herbivores may be the host of a large number of lice which live as parasite.

3. Detritus food chain:

It starts from dead organic matter and ends in inorganic compounds. There are certain groups of organisms which found on the dead bodies of animals and plants. These organisms are called detritivores.

The detritivores include algae, bacteria, fungi, protozoans, insects, millipedes, centipedes, mussels, nematodes etc. These organisms ingest and digest the dead organic materials.

This type of food chain goes from dead organic matter into microorganisms and then to organisms feeding on detritus (detritivores) and then predators. Such ecosystems are thus less dependent on direct sunlight.

A good example of this food chain is based on mangrove leaves.
Leaves fallen in shallow water ⟶ Saprotrophs (fungi, bacteria, protozoa) ⟶ Eaten & re-eaten by small organisms (crabs, copepods, insect larvae, shrimps, bivalves etc.) ⟶ Small carnivores (fish) ⟶ Top carnivores (birds).

Thus the detritus food chain ends in a similar manner to the grazing food chain, but the way in which the two chains begin is different.

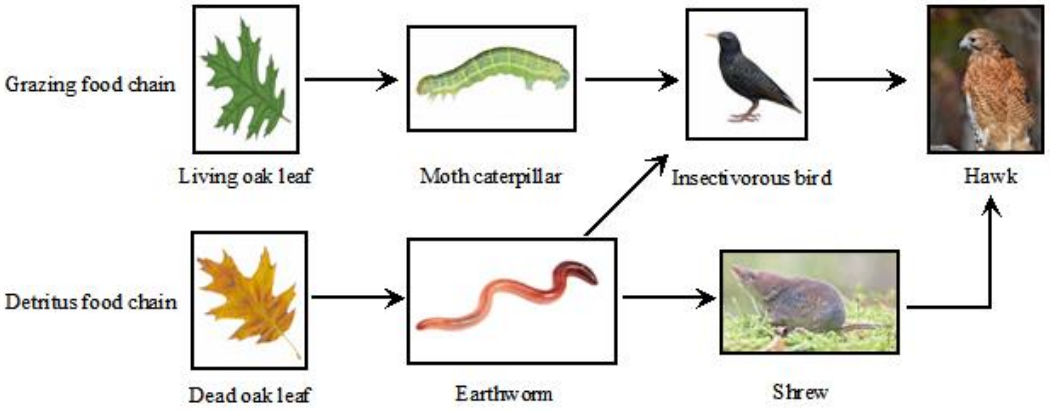
Linking of Grazing and Detritus food chains:

The two main food chains can not operate independently. They are interconnected at various levels. According to **Wilson and Bossert** (1971) the stabilty of the ecosystem is directly proportional to the number of such links.

The detritus feeder obtain energy from the dead bodies of animals and palnts which are components of the grazing food chain.

Again some of the detritus feeders are eaten by the consumers of the grazing food chain.

E,g, In a grassland ecosystem, earthworms belonging to detritus food chain are eaten by birds of the grazing food chain.



FOOD WEB

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

"The interlocking of many food chains is called food web".

Simple food chains are very rare in nature. This is because, each organism may obtain food from more than one trophic level. In other words, one organism forms food for more than one organism of the higher trophic level.

An organism may form a food source for many other organisms, thus forming a web.

Example: - In a grassland ecosystem, grass is eaten by grasshopper, rabbit and mouse. Grasshopper is eaten by lizard which is eaten by hawk. Rabbit is eaten by hawk. Mouse is eaten by snake which is eaten by hawk.

The hawks also directly eat grasshopper and mouse. Thus, there are five linear food chains which are interconnected to form a food web.

1) Grass → Grasshopper → Hawk
2) Grass → Grasshopper → Lizard → Hawk
3) Grass → Rabbit → Hawk
4) Grass → Mouse → Hawk
5) Grass → Mouse → Snake → Hawk

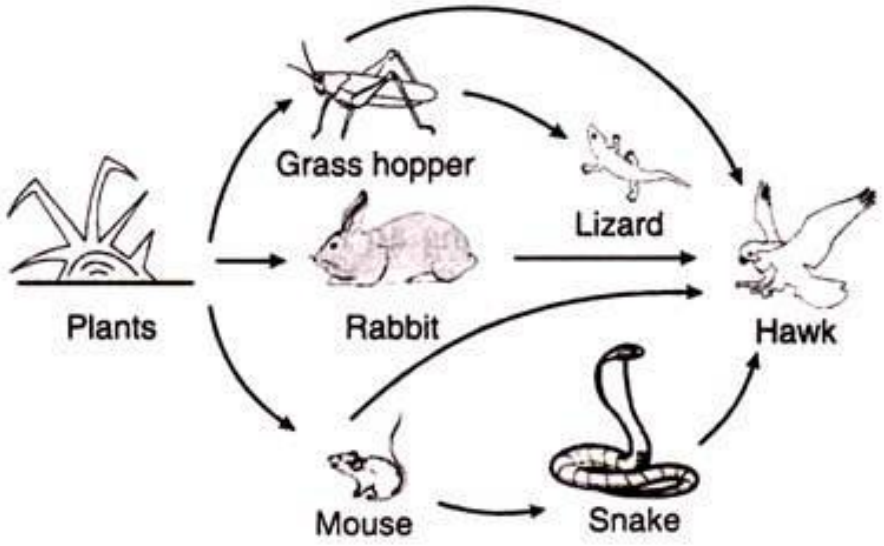


Fig. 5. Food web in a grassland ecosystem.

This is a very simple food web. But in any ecosystem the food web is more complex. e.g. In the grassland, in addition to hawk, there are many other carnivores such as vulture, crow, wolf, fox, man etc.

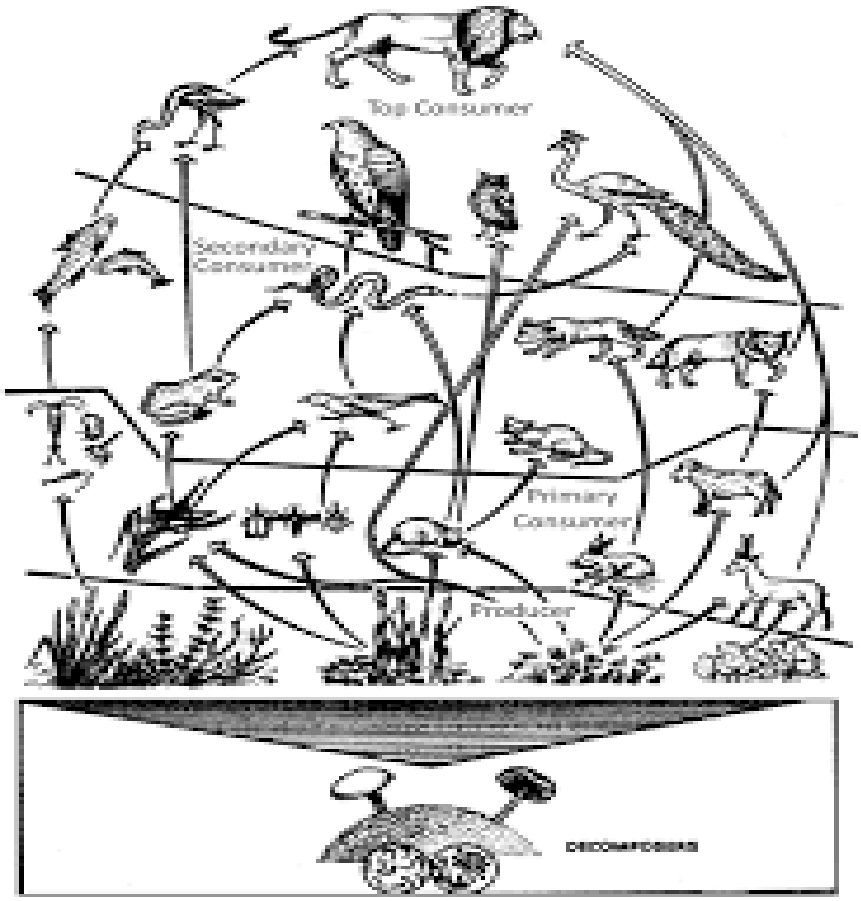


Fig. Food Web

Significance of food web:

Food webs are very important in maintaining the stability of an ecosystem.

e.g. The deleterious growth of grasses is controlled by the herbivores. When one type of herbivore becomes extinct, the other types of herbivores increase in number and control the vegetation.

Similarly, when one type of herbivorous animal become extinct, the carnivore predating on this type may eat another type of herbivore.

Thus, each species of any ecosystem is kept under some sort of natural check, so that the system may remain balanced.

Difference between food chain and food web:

In a food chain, many trophic levels are linked.

In a food web, many food chains are linked.

Energy Flow through the Ecosystem:

"The transfer of energy from one trophic level to another trophic level is called **energy flow**".

The producers synthesize and store energy in their body by photosynthesis. When the consumers eat the producers, the energy is transferred to the body of consumers.

The flow of energy in an ecosystem is **unidirectional**, i.e. it flows from the producer level to the consumer level and never in the reverse direction. Hence, energy can be used only once in the ecosystem.

When the herbivores eat the producers the energy is transferred to the body of herbivores, but only 10% is stored. The remaining 90% is lost through faeces, respiration and unused energy.

A large amount of energy is lost at each trophic level. It is estimated that 90% of the energy is lost when it is transferred from one trophic level to another. Hence the amount of energy available decreases from step to step.

When the food chain is short, the final consumers may get a large amount of energy. But when the food chain is long, the final consumer may get a lesser amount of energy.

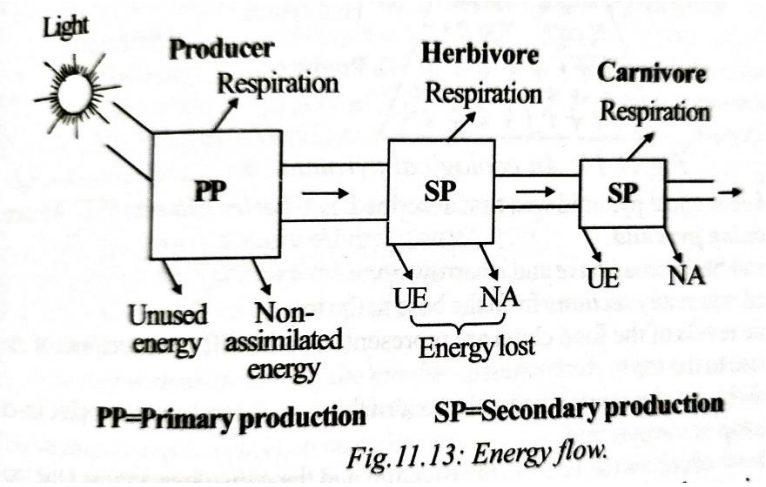


Fig.11.13: Energy flow.

Let us assume that the total amount of energy stored in the producers is 15 calories. When the producers are eaten by herbivores only 10% 1s transferred to the body of herbivores. Only about 1.5 calories (10%) is incorporated into the body of herbivores.

When the herbivore is eaten by the carnivore, again only 10% i.e., 0.15 calories is incorporated into the body of carnivores. The remaining 90% is lost as heat

The energy flow in the ecosystem follows the two laws of thermodynamics.

The first law states that 'energy can neither be created nor destroyed; it can simply change in form'.

The light energy of the Sun is converted into electrical energy in the chlorophyll. The electrical energy is converted into chemical energy during photosynthesis.

The chemical energy is transformed into heat energy during metabolism. The heat energy is transformed into mechanical energy for doing work. Thus, the first law is obeyed.

The second law states that 'during energy transfer, large part of energy is degraded into heat and dissipates'. When energy is transferred from producers to herbivores about 90% of energy is lost as heat.

Ecological Pyramids

Ecological pyramids is the geographical representation of the number, biomass and energy of organisms of the successive trophic levels of an ecosystem.

Trophic level: It is a step in a food chain. It explains the position of each organism in the food chain.

"The number, biomass and energy of organisms gradually decrease from the producer level to the consumer level. This can be represented in the form of a pyramid, called as ecological pyramid".

The use of ecological pyramid was first described by **Charles Elton** in 1927. Hence it is called **Eltonian pyramid**.

In the ecological pyramid, the producers form the base and the final consumer occupies the apex. It is divided into many sections from the base to the top.

There are three types of ecological pyramids:

1. Pyramid of numbers
2. Pyramid of biomass
3. Pyramid of energy

1) Pyramid of Numbers:

In the pyramid of numbers, the number of individuals of each trophic level is represented. They show the relationship between producers, herbivores and carnivores at each trophic levels in terms of their number.

The number of individuals at the trophic level decreases from the producer level to the consumer level. The number of producers in an ecosystem is very high.

The number of herbivores is lesser than the producers. Similarly, the number of carnivores is lesser than the herbivores.

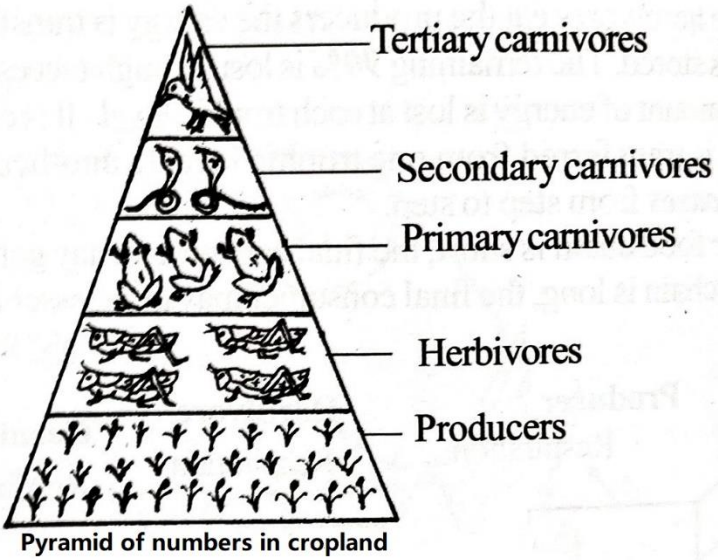
e.g. i) In croplands, the crops (producers) are more in numbers

The grasshoppers feeding on crop plants are lesser in number.

The frogs feeding on grasshoppers are still lesser in number.

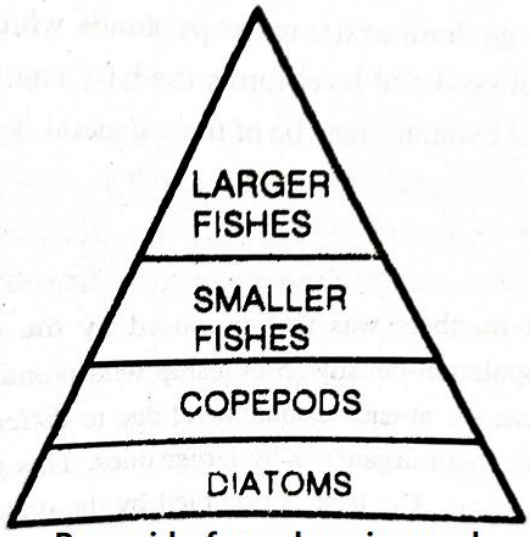
The snakes feeding on frogs are fewer in number.

Crop ⟶ Grasshopper ⟶ Frog ⟶ Snake ⟶ Hawk



Pyramid of numbers in cropland

ii) In pond ecosystem, the base is occupied by the diatoms and they are large in numbers. The second trophic level is occupied by the copepods, which are lesser then diatoms. The third and fourth levels contain the smaller and larger fishes respectively. There is reduction in the number of individuals and increase in size of body from base to top of the pyramid.

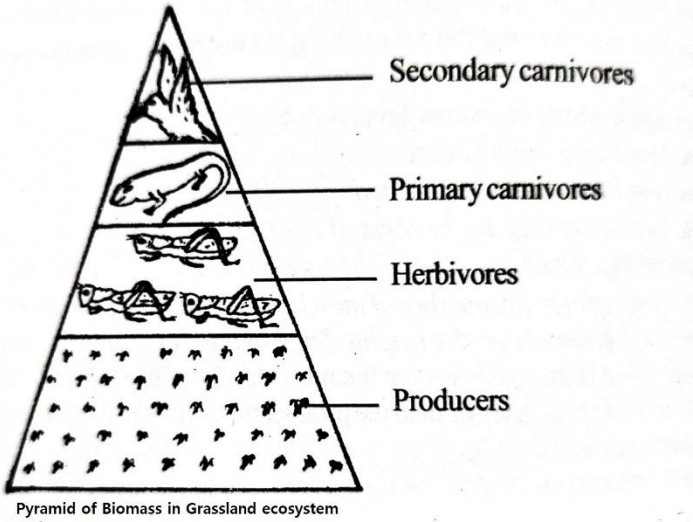


Pyramid of numbers in pond

2) **Pyramid of Biomass:** (Biomass= the total weight of living matter per unit area)
In the pyramid of biomass, the weight of living matter of each trophic level is represented. In an ecosystem, the biomass decreases from the producer level to the consumer level.

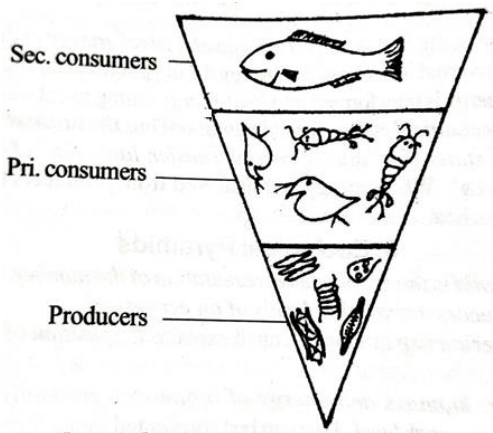
In the pyramid of biomass, the weight of individuals in each trophic level is considered instead of counting them.

e.g. i) In grassland and forest, there is generally a gradual decrease in biomass of organisms from producers to the top carnivores. Thus, pyramids are upright.



Pyramid of Biomass in Grassland ecosystem

ii) In a pond ecosystem, the producers are small organisms, their biomass is least. The biomass gradually increases towards the apex of the pyramid. Thus, pyramid becomes inverted.



Inverted pyramid of biomass in a pond ecosystem.

3) Pyramid of Energy:

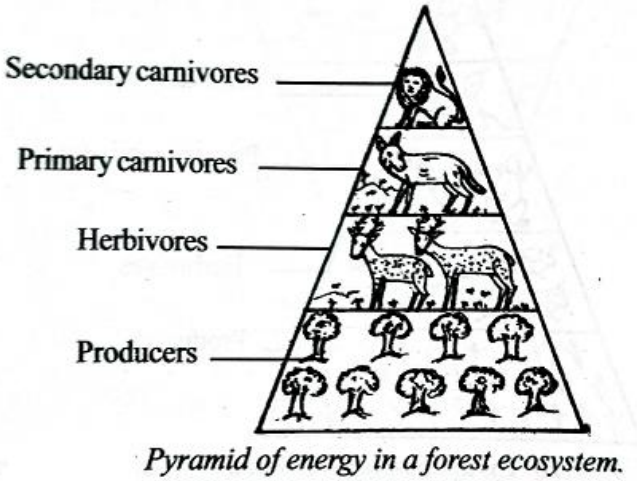
In the pyramid of energy, the energy content of each trophic level is represented.

The energy in an ecosystem flow from the producer level to the consumer level. At each trophic level 80-90% of energy is lost. Hence the amount energy decreases from the producer level to the consumer level. This can be represented in a pyramid of energy.

e.g. An ecosystem receives 1000 calories of light in a given day. Most if the energy is not absorbed; some is reflected back to space. Only a small portion is used by green plants, out of which the plants use some part of energy for respiration, growth and repair. From the 1000 calories, only 100 calories are stored as energy rich materials. When a herbivore eats the plant, receives 100 calories of food energy (e.g. Deer).

The herbivores (Deer) use some of it for it's own metabolism and stores only 10 calories as food energy. When a carnivore (e.g. Lion) eats the herbivore (Deer) gets even smaller amount of energy (i.e., 1 calory).

Therefore, energy pyramid will always be upright.



Pyramid of energy in a forest ecosystem.

CONCEPT OF EUTROPHICATION IN LAKES AND RIVERS

Most elements required for plant growth are available in excess in a well-established lake. A few elements are present in quantities close to the required for plant growth and when present in insufficient quantities will be limiting factors. They maintain a balance in the lake. Increase in the amount of these limiting factors results in the process of eutrophication. [Eutroph= rich]

"Eutrophication is the process in which a water body becomes excessively rich with nutrients as phosphates and nitrates resulting into explosive growth of the aquatic plants".

Eutrophication denotes the enrichment of a water body by input of organic waste, containing nutrients, chiefly nitrates and phosphates. Sewage and domestic waste water contain these nutrients. The decomposition of organic matter makes the water rich in nutrients. Due to phosphates and nitrates, the water body becomes highly productive or eutrophic and the phenomenon is called eutrophication.

Natural Eutrophication:

Natural eutrophication is a very slow process, taking often a period of over hundred years. Many nutrients result from the natural disintegration of rocks and from mineralisation of organic matter. Ponds, lakes and rivers during their early stages of formation are relatively barren and nutrient deficient. Thus, such water bodies support very poor aquatic life.

When water bodies are not enriched with nutrients they are called oligotrophic and they have very small plant and animal populations and very clear, blue water.

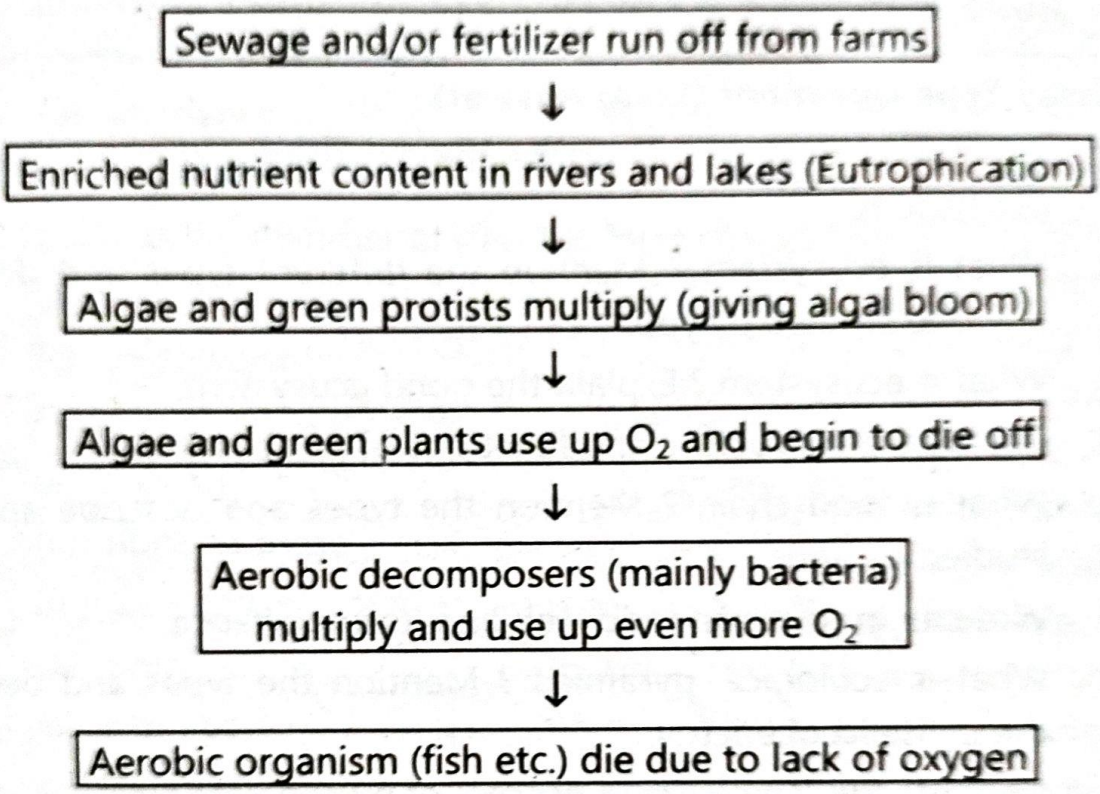
Artificial Eutrophication:

It's due to human activities, which is a fast process. This happens when domestic waste, agricultural residues, land drainage and industrial wastes reach a water body. Addition of nutrients stimulates luxuriant growth of algae in water. Also, the algal flora and blue green algae begin to predominate, this forms algal blooms. The algal blooms are not utilised by zooplanktons. The algal blooms compete with other aquatic plants for photosynthesis. The other aquatic plants also flourish in water, as a result of additional nutrients. The water becomes turbid and greenish.

As more plants grow, more also die and decay. Both these processes consume O_2 resulting in depletion of O_2. Nutrient and organic wastes added by people imbalance the cycle. Addition of nutrients at an increased rate increases the rate of growth of algae. As the algae die, they add to wastes. These algal blooms also release some toxic chemicals which kill fishes and other aquatic animals, thus water begins to stink.

The waterbodies become poorly oxygenated with higher CO_2, levels. It further kills fish and other aquatic animals. Such water body is said to be eutrophic. It smells offensively as BOD rises and its aesthetic value goes down. Thus, Eutrophication is a limiting factor in supply of clean water for drinking, fishing and navigation.

Example: The excellent example of manmade eutrophication is Lake Erie in U.S.A. In 1965, more than 80 tonnes of phosphates were added daily in this lake. Each 400 gm of phosphate produce 350 tonnes of algal slime. There were big mounds formed on the shore by algal growth which produced unpleasant odour, clogging of pipes and interfering with fishing and navigation. Eutrophication usually has an adverse effect on fishing.


Sewage and/or fertilizer run off from farms
Enriched nutrient content in rivers and lakes (Eutrophication)
Algae and green protists multiply (giving algal bloom)
Algae and green plants use up O_2 and begin to die off
Aerobic decomposers (mainly bacteria) multiply and use up even more O_2
Aerobic organism (fish etc.) die due to lack of oxygen