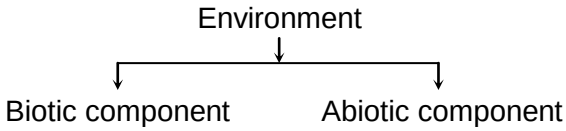
The physical and biological world where we live is called as our environment. It has two components:



Biotic component : It is the living component of the environment. All the living organisms are included in it.
Abiotic component : It is the non-living component of the environment. The abiotic components are the physical factors such as :

(i) Climatic factors like light, wind, humidity, temperature, precipitation etc.
(ii) Edaphic factors like soil texture, minerals, pH, topography etc.

1. ECOSYSTEM

All organisms such as plants, animals, microorganisms and human beings as well as the physical surroundings interact with each other and maintain a balance in nature. All the interacting organisms in an area together with the non-living constituents of the environment form an ecosystem.

Thus, ecosystem is a self-sustaining, structural and functional unit of biosphere, for e.g. a grassland, a forest, a desert, a mountain, a pond, a lake and sea. The term 'ecosystem' was introduced by Tansley in 1935.

An ecosystem needs only the input of sunlight for its functioning.

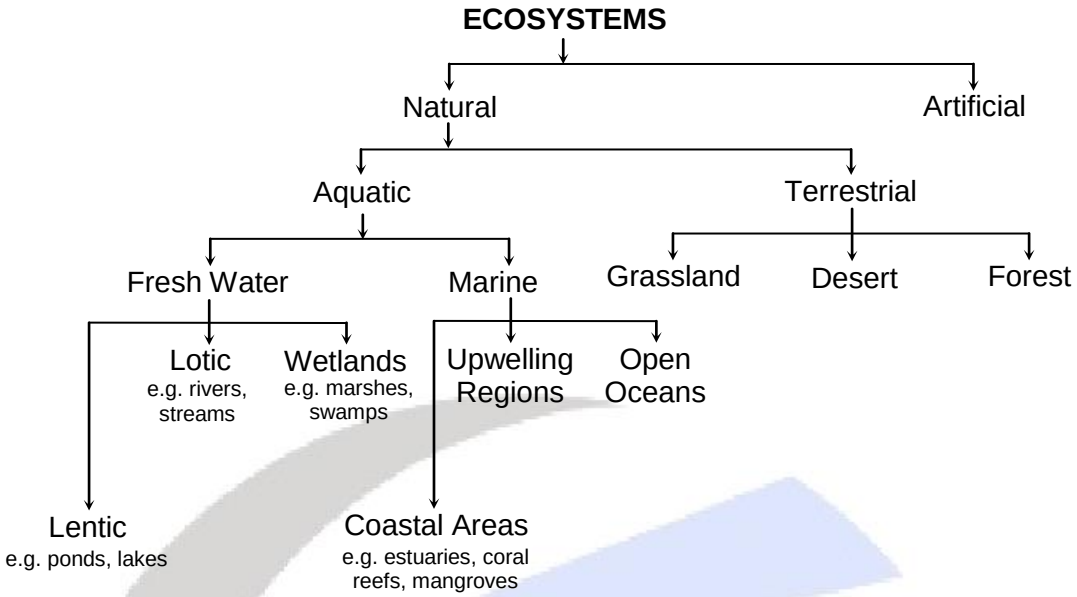
1.1 TYPES OF ECOSYSTEMS

In the biosphere, ecosystems may be classified on the basis of their nature, duration and size :

(i) Nature : On the basis of nature, ecosystems may be classified as :
- **(a) Natural ecosystems :** These ecosystems operate in the nature by themselves without any human interference. Common examples of natural ecosystems are : a pond, a lake, a meadow, a desert, a grassland, a forest, an ocean etc.
- **(b) Artificial ecosystems :** These are maintained by man and hence are also termed man-made or man-engineered ecosystem. In these ecosystems, man maintains the natural balance by the addition of energy and planned manipulations. Common examples of artificial ecosystems are cropland, orchard, garden, aquarium etc.

(ii) Duration : On the basis of duration, ecosystems may be classified as :
- **(a) Temporary ecosystems :** These are short-lived ecosystems which may be natural or man-made. Common examples include rainfed pond and laboratory culture of protozoans.
- **(b) Permanent ecosystems :** These are self-supporting natural ecosystems that maintain themselves for relatively long duration, e.g., a lake, a forest, a desert etc.

(iii) Size : On the basis of size, ecosystems may be classified as :
- **(a) Small ecosystems :** Small-sized ecosystems are also termed as micro-ecosystems, e.g. a flowerpot, water in a dish, a site under a stone etc.
- **(b) Large ecosystems :** Very large-sized ecosystems are also termed macro-ecosystems, e.g., an ocean, a forest, a desert etc.



1.2 COMPONENTS OF AN ECOSYSTEM

All the ecosystems are made up of two main components. They are :

(i) Abiotic (non-living) component : These include the non-living physico-chemical factors of the environment. These components not only affect the distribution and structure of organisms but also their behaviour and inter relationships. Abiotic factors include:

- **(a) Inorganic substances:** Inorganic substances, e.g., carbon, nitrogen, oxygen, calcium, phosphorus etc. and their compounds (water, carbon dioxide, etc.) constitute the main abiotic component. These occur either in the form of compounds dissolved in water, in the soil or in free state in air.
- **(b) Organic compounds:** These include carbohydrates, proteins, lipids, nucleic acids etc. These are present in living organisms and dead organic matter. The dead organic matter is broken down by the action of decomposers (e.g., bacteria, fungi) into inorganic substances for their recycling.
- **(c) Climatic factors:** These include light, temperature, humidity, wind, rainfall, water etc. and also edaphic factors (e.g., soil, topography, minerals, pH etc.).

(ii) Biotic (living) components: The biotic component of an ecosystem (or the living component of an ecosystem) is a community of organisms (like plants and animals), which is made up of many different inter-dependent populations. The biotic community (or living community) of an ecosystem includes three types of organisms:

- **(a) Producer organisms (or Autotrophs)** which synthesize their own food. All the green plants are producers.
- **(b) Consumer organisms (or Heterotrophs)** which are dependent on others for food. All the animals are consumers.
- **(c) Decomposer organisms (or Saprotrophs)** which consume the dead remains of other organisms. Certain bacteria and fungi are decomposers.

Let us understand them in detail :

1.2.1 Producers

Those organisms which produce food are called producers. Producers are the organisms which can prepare their own food from simple inorganic substances like carbon dioxide and water by using sunlight in the presence of chlorophyll. The examples of producers are green plants and certain blue-green algae. The green plants synthesize their food during photosynthesis by taking raw materials

from the earth and energy from the sun. Producers are the autotrophic organism (self-feeder organisms) in the ecosystem upon which other organisms depend for food. Thus, producers (like green plants) are autotrophs.

1.2.2 Consumers

Those organisms which consume food (eat food) prepared by producers are called consumers. The consumers depend on producers for food, directly or indirectly. The consumers get their food by eating other organisms or their products. All the animals are consumers. They are known as heterotrophs. Consumers can be further divided into three groups: herbivores, carnivores and omnivores.

(i) Herbivores : Some animals eat only plants (or their products). Those animals which eat only plants are called herbivores. The herbivores may eat grasses, leaves, grains, fruits or the bark of trees. Some of the examples of herbivores are: cow, buffalo, goat, sheep, horse, deer, camel, ass, ox, elephant, monkey, squirrel, rabbit and hippopotamus. Since herbivores obtain their food directly from plants (or producers), therefore, herbivores (like cattle, deer, goat, etc.) are **primary consumers**.

(ii) Carnivores : Some animals eat only other animals. They do not eat plant food at all. Those animals which eat only other animals as food are called carnivores. Some of the examples of the carnivores are : lion, tiger, frog, vulture, kingfisher, lizard, wolf, snake and hawk. The carnivores are usually of two types (a) small carnivores and (b) large carnivores. The small carnivores which feed on herbivores (primary consumers) are called secondary consumers. For example, a grasshopper, rat, seed eating birds and frog, etc., are **secondary consumers**. The large carnivores (or top carnivores) which feed upon the small carnivores (secondary consumers) are called tertiary consumers. For example, lion, tiger, birds of prey (such as hawk) and humans (man) are some of the **tertiary consumers**.

(iii) Omnivores : Some animals eat both, plants as well as other animals. Those animals which eat both, plants and animals, are called omnivores. Some of the examples of omnivores are: man (human beings), dog, crow, sparrow, bear, mynah and ant.

1.2.3 Decomposers

The micro-organisms which break down the complex organic compounds present in dead organisms like dead plants and animals and their products like faeces, urine, etc., into simpler substances are called decomposers. The examples of decomposers are certain bacteria and fungi. The bacteria which act as decomposers are called putrefying bacteria.

Importance of Decomposers

The decomposers help in decomposing the dead bodies of plants and animals, and hence act as cleansing agents of environment. Thus, it is only due to the presence of decomposers that the various nutrient elements which were initially taken by plants from the soil, air and water are returned to the soil, air and water, after the death of plants and animals. In the absence of decomposers, the soil, air and water would not be replenished by elements from the bodies of dead organisms. Thus, the decomposer organisms help in recycling the materials in the ecosystem so that the process of life may go on and on like an unending chain.

2. FOOD CHAIN

Anything which an organism eats to live and survive is called food. Food provides the necessary energy requirement to an organism.

In any given ecosystem, all living organisms are linked in a systematic chain with respect to their mode of manufacturing food/feeding habits. The interactions among various components of the environment involves flow of energy from one component of the ecosystem to other.

Examples : In a grassland ecosystem, all green plants (herbs, shrubs and trees) are **producers.** These **autotrophs** manufacture their food by utilizing the radiant energy of the sun by the process of photosynthesis. During photosynthesis, producers capture solar energy and convert it into chemical energy. These autotrophs (producers) are eaten up by plant eaters, i.e., **herbivores (primary consumers).** The herbivores are subsequently eaten up by flesh eating animals, *i.e.,* **carnivores (secondary consumers).** The carnivores may be eaten up by **larger carnivores (tertiary consumers).** Thus, we find that starting with the producers, upto herbivores, carnivores and next level carnivores, all organisms are inter-linked in a definite sequence and involve transfer of energy from producers onward to the last link in the chain. This sequential interlinking of organisms involving transfer of food and energy from the producers, through a series of organism with repeated eating and being eaten is the food chain.

That is, the sequence of living organisms in a community in which one organism consumes another organism to transfer food and energy is called the food chain.

2.1 EXAMPLES OF FOOD CHAIN

A food chain represents a single directional transfer of energy. For example:

2.1.1 Food Chain in forest

In this food chain, grass is the producer organism which uses sunlight energy to prepare food like carbohydrates by the process of photosynthesis. This grass is then consumed by a herbivore like deer. And the deer is consumed by a carnivore like lion.

Grass (Producer) ⟶ Deer (Herbivore) ⟶ Lion (Carnivore)

2.1.2 Food chain in a glass land

In this food chain grass is the producer. The insects (herbivore) are the primary consumer, the frog (small carnivore) and snake are the secondary consumers whereas the bird (top carnivore or large carnivore) is the tertiary consumer.

Grass (Producer) ⟶ Insects (Herbivore) ⟶ Frog (Carnivore) ⟶ Snake (Carnivore) ⟶ Birds (Top carnivore or Large carnivore)

2.1.3 Food chain in a pond

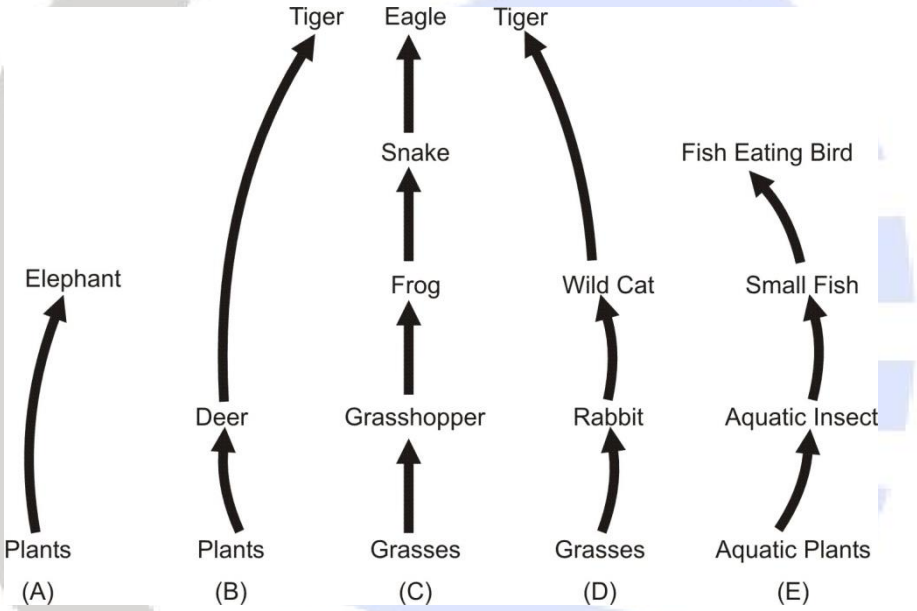
The food chain operating in the aquatic ecosystem (water ecosystem) like a pond, lake, or sea (ocean).

Algae ⟶ Scorpion ⟶ Small Fish ⟶ Swan
(Producer) (Herbivore) (Carnivore) (Large carnivore)

In this aquatic food chain, algae is the producer. The scorpion is the primary consumer, small fish is the secondary consumer. Swan is the tertiary consumer.

2.2 LENGTH OF FOOD CHAIN

In different ecosystems, different food chains may have two, three, four or maximum five trophic levels. Such food chains in different ecosystems are depicted in figure given below. Accordingly, a food chain may end at the (i) herbivore (primary consumer) level, (ii) primary carnivore (secondary consumer) level, (iii) secondary carnivore (tertiary consumer) level or (iv) tertiary carnivore (quaternary consumer) level.

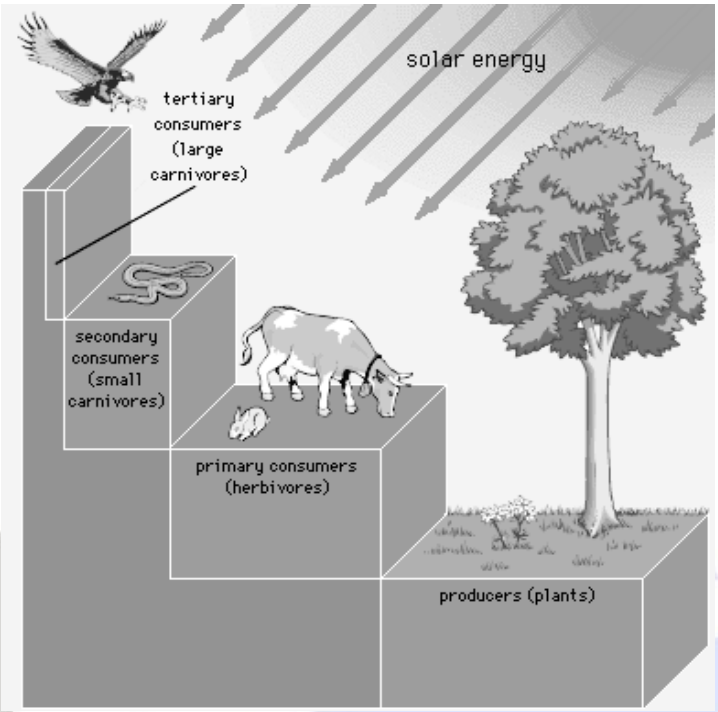


Food chains in nature. (A) Two-step food chain in forest, (B) Three-step food chain in a forest, (C) Five-step food chain in a grassland, (D) Four-step food chain in a grassland, and (E) Four-step food chain in a pond.

2.3 TROPHIC LEVEL

Each step or level of the food chain forms a trophic level.

(i) The autotrophs or the producers are at the first trophic level. They fix up the solar energy and make it available for heterotrophs or the consumers.
(ii) The herbivores or the primary consumers come at the second.
(iii) The small carnivores or the secondary consumers are at the third trophic level.
(iv) The larger carnivores or the tertiary consumer form the fourth trophic level.

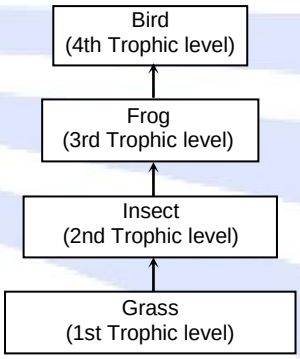


Trophic levels

For Example : food chain operating in the grassland, which is:

Grass ⟶ Insects ⟶ Frog ⟶ Birds

In this food chain, grass represents the 1st trophic level; insect represents the 2nd trophic level; frog represents the 3rd trophic level, whereas bird represents 4th trophic level.



Trophic levels in food chain

2.4 CHARACTERISTICS OF A FOOD CHAIN

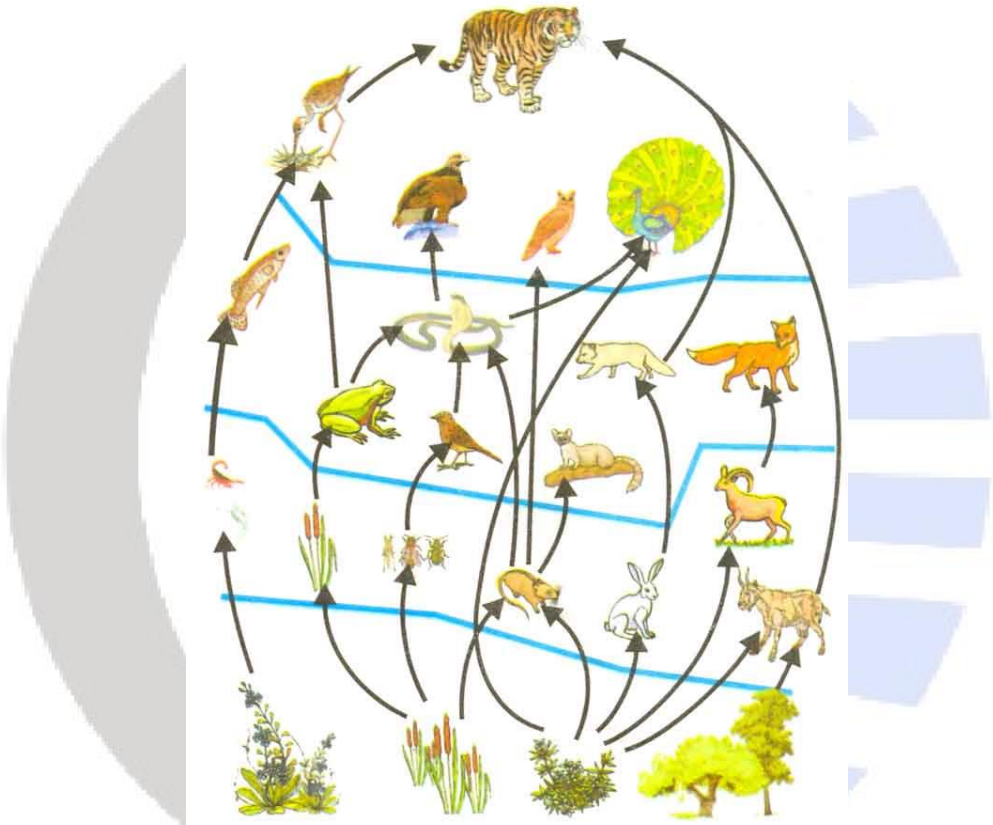
1. A food chain involves a nutritive interaction between the living organisms (biotic components) of an ecosystem. In a food chain, there occurs **repeated eating,** i.e., each group eats the other group and subsequently is eaten by some other group of organisms.
2. A food chain is **always straight** and proceeds in a progressive straight line.
3. In a food chain, there is **unidirectional flow of energy** from sun to producers and subsequently to series of different types of consumers.
4. Usually, there are 3 or 4 trophic levels in the food chain. In few chains, there may be maximum of 5 trophic levels.
5. Some organisms are **omnivores.** These occupy different trophic positions in different food chains.

6. At each transfer, generally 80-90% of energy is lost as heat in accordance with second law of thermodynamics.

3. FOOD WEB

The length and complexity of food chains vary greatly. Each organism is generally eaten by two or more other kinds of organisms which in turn are eaten by several other organisms. So instead of a straight line food chain, the relationship can be shown as a series of branching lines which is a food web.

The inter-connected food chains operating in an ecosystem which establish a network of relationships between various species, is called a food web. That is, the network of a large number of food chains existing in an ecosystem is called a food web.



Food web, consisting of many food chains

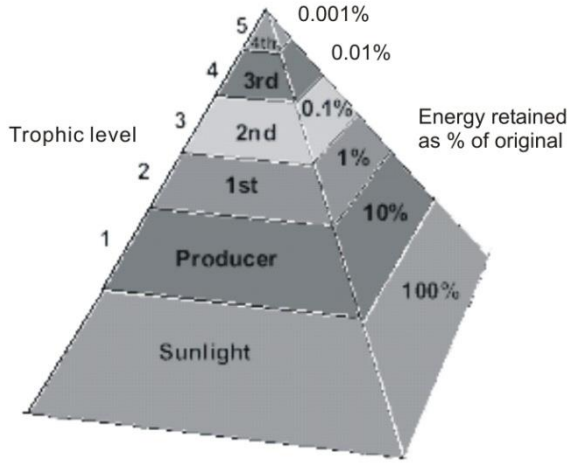
3.1 CHARACTERISTICS OF A FOOD WEB

1. Unlike food chains, food webs are **never straight.** Instead, each food web is formed by **interlinking of food chains.**
2. A food web provides **alternative pathways** of food availability. For example, if a particular species of producer is destroyed by a disease in the ecosystem, the herbivores of that area can feed on other species of producers. Similarly, secondary consumers (e.g., predatory birds) may feed on rats or mice in the event of decrease in population of rabbits in that area on which they also commonly feed.
3. Greater alternatives available in a food web make the ecosystem more **stable.**
4. Food webs also help in **checking the overpopulation** of highly fecundive species of plants and animals.
5. Food webs also help in ecosystem development.

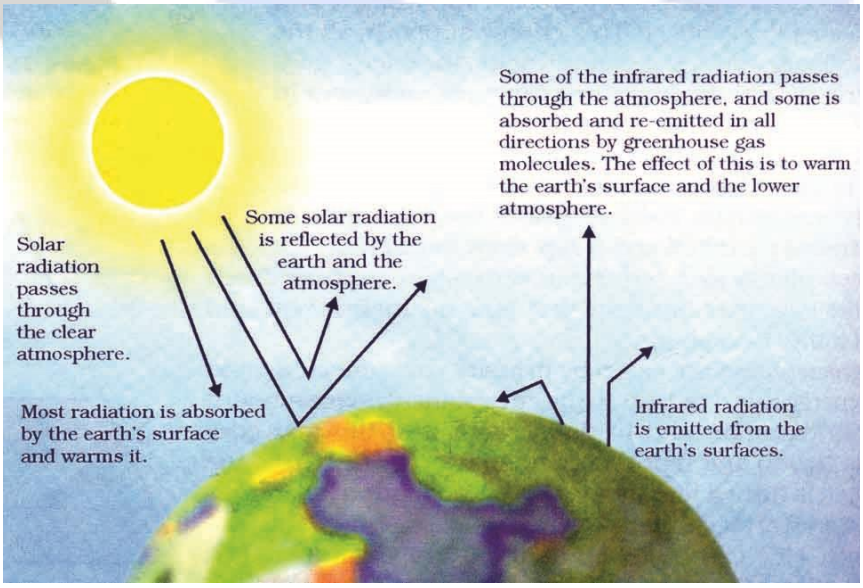
3.2 FLOW OF ENERGY

Each organism needs energy to carry on vital activities, and for building up and repairing the body tissues.

- The ultimate source of entire energy, used by living organisms, is the **sun.**
- Of the total solar radiations falling on the earth, only about 1% are captured by green plants in a terrestrial ecosystem and converted into food energy by photosynthesis.
- When green plants are eaten by herbivores (primary consumers), a great deal of energy is lost as heat to the environment in accordance with the second law of thermodynamics. Some amount of energy is used in doing work and the remaining goes towards growth and reproduction. On an average, 10% of the food eaten is turned into body of herbivores and is made available for the next level of consumers. In other words, on an average, 10% of the amount of organic matter that is present at each step reaches the next consumer level.



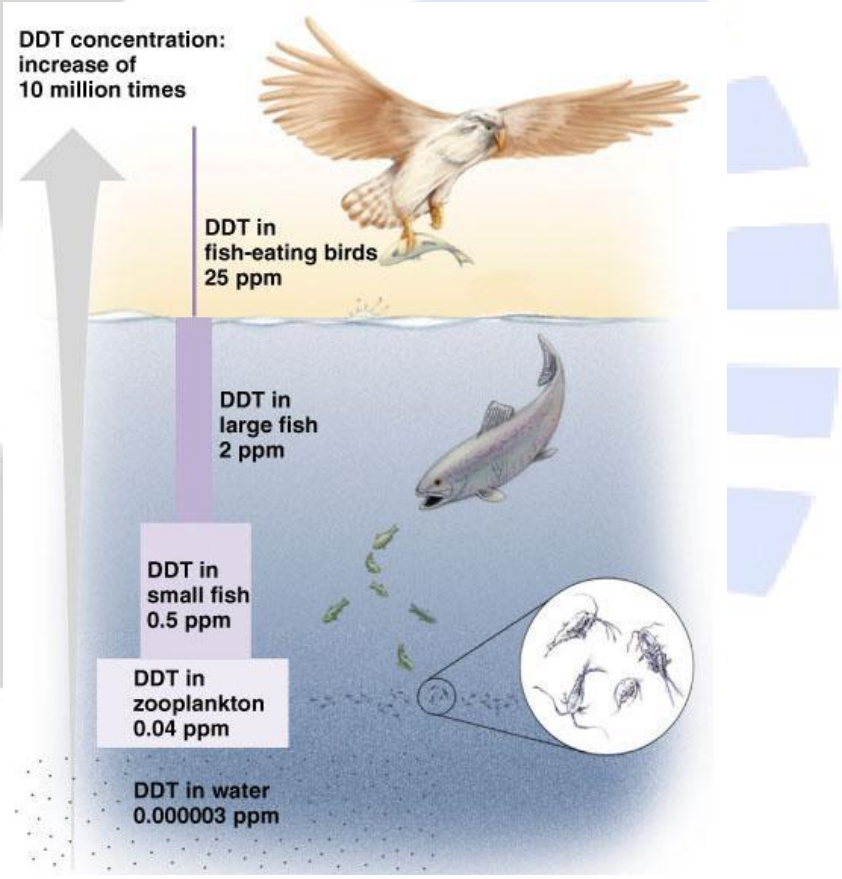
- Since, amount of available energy goes on decreasing at each trophic level, food chains usually consist of only 3 or 4 steps and rarely maximum of 5 steps.
- In an ecosystem, generally, the producers are maximum in number. As we move along the chain, number of individuals at each trophic level decreases.



Flow of energy in an ecosystem

From the energy flow diagram two things become clear. Firstly, the flow of energy is unidirectional. The energy that is captured by the autotrophs does not revert back to the solar input and the energy which passes to the herbivores does not come back to autotrophs. As it moves progressively through the various trophic levels it is no longer available to the previous level.

Another interesting aspect of food chain is how some harmful chemicals enter our bodies through the food chain. In water pollution, one of the reasons is the use of several pesticides and other chemicals to protect our crops from diseases and pests. These chemicals are either washed down into the soil or into the water bodies. From the soil, these are absorbed by the plants along with water and minerals, and from the water bodies these are taken up by aquatic plants and animals. This is one of the ways in which they enter the food chain. As these chemicals are not bio-degradable, these get accumulated progressively at each tropic level. As human beings occupy the top level in any food chain, the maximum concentrations of these chemicals get accumulated in our bodies. This phenomenon is known as **biological magnification**. This is the reason why our food grains such as wheat and rice, vegetables and fruits, and even meat, contain varying amounts of pesticide residues. They cannot always be removed by washing or by other means.



Bio-magnification

4. HOW DO OUR ACTIVITIES AFFECT THE ENVIRONMENT?

We are an integral part of the environment. Our activities change the environment around us. These changes in the environment then affect us. Let us discuss two environmental problems caused by human activities :

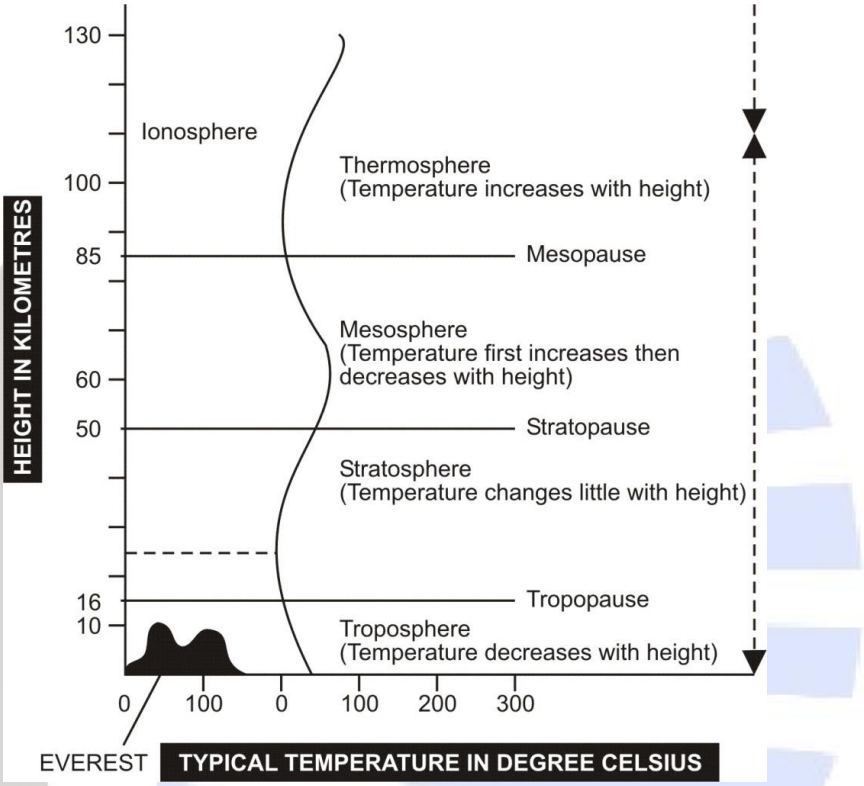
(i) Depletion of the Ozone layer.

(ii) Waste disposal

4.1 OZONE LAYER AND ITS DEPLETION

The global environment is basically formed by three parts – atmosphere, hydrosphere and lithosphere. The atmosphere extends over about 600 km from the earth's surface. Four layers of atmosphere are – troposphere, stratosphere, mesosphere and thermosphere.

Ozone layer, commonly called ozone blanket, comprises of high concentration of ozone about 18-26 km above in the stratosphere. As per estimates, 90% of the total atmospheric ozone is present in this region.



Main layers of the atmosphere. These are shown between solid lines. The vertical wavy line depicts temperature variation with increasing height.

4.1.1 Formation of ozone

Ozone is a form of oxygen. Ozone (O_3) is a molecule formed by three atoms of oxygen. While O_2, which we normally refer to as oxygen, is essential for all aerobic forms of life. Ozone at the higher levels of the atmosphere is a product of UV radiation acting on oxygen (O_2) molecule. The higher energy UV radiations split apart some molecular oxygen (O_2) into free oxygen (O) atoms. These atoms then combine with the molecular oxygen to form ozone.

$$O_2 \xrightarrow{UV} O + O$$

$$O + O_2 \longrightarrow O_3 \quad \text{(Ozone)}$$

4.1.2 Function of ozone

Ozone is a poisonous gas but is not stable nearer to earth's surface. It performs an essential function where it is found. It absorbs the harmful radiations from the Sun. It shields the surface of the earth from the ultraviolet (UV) radiation of the sun. Absorption of UV radiations by ozone blanket is proportional to its thickness.

4.1.3 Ozone depletion

The thinning of ozone layer is commonly called ozone depletion. Ozone is being depleted by air pollutants. Chlorofluorocarbons (CFC's) are the air pollutants that are mainly responsible for the depletion of ozone layer in the stratosphere. Besides, methane (CH_4) and oxides of nitrogen (NO_x) also cause destruction of ozone.

4.1.4 Chlorofluorocarbons – the main culprit

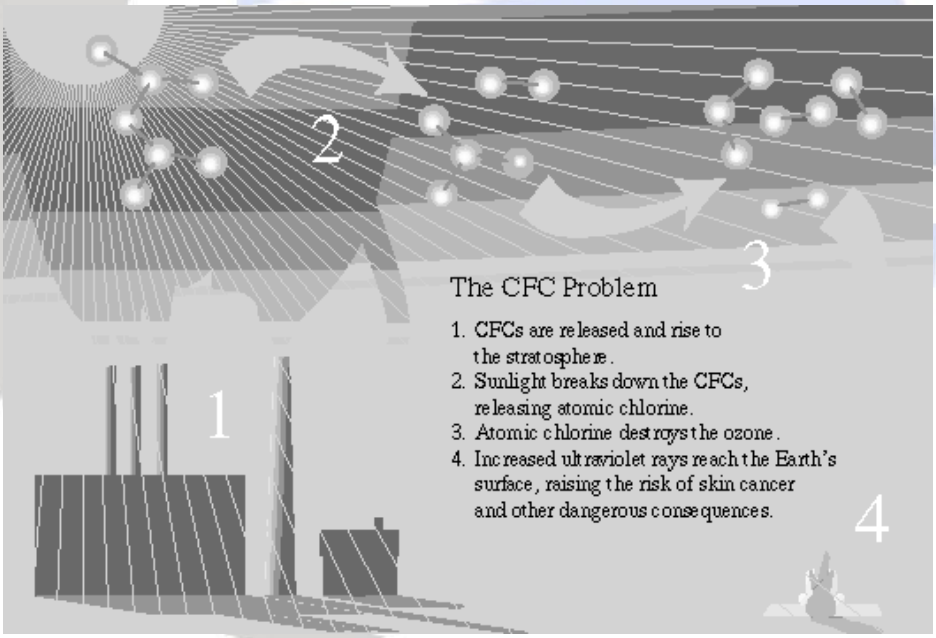
They are the carbon compounds containing both fluorine and chlorine. They are very stable and not degraded by any biological process and are found to persist in the atmosphere.

They are widely used as coolants in :

(i) Refrigerators
(ii) Air conditioners
(iii) Fire extinguishers
(iv) Aerosol sprays
(v) Propellants

4.1.5 How ozone layer is getting depleted?

Chlorofluorocarbons, once released in air, reach the ozone layer. Then, they produce 'active chlorine' (Cl and ClO radicals) in the presence of UV radiations. These radicals, through chain reactions, then destroy the ozone by converting it into oxygen. Due to this, the ozone layer in the upper atmosphere (i.e. stratosphere) becomes thinner.



Depletion of ozone layer

4.1.6 Effects of ozone depletion

The thinning of ozone layer allows more ultraviolet (UV) radiations to pass through it which then strike the earth. These cause following harmful effects on man and animals :

(i) Skin cancer.
(ii) Damage to eyes and also increased incidence of cataract disease in eyes.
(iii) Damage to immune system.

4.1.7 Saving the ozone layer

The thinning of ozone layer started in 1980s. In 1987, the United Nations Environment Programme (UNEP) succeeded in forging an agreement to freeze CFC production at 1986 levels.

4.2 WASTE AND ITS DISPOSAL

In our daily life, we generate a lot of materials and throw them away. These household wastes (or rubbish) are called garbage. This garbage includes left over food, fruit and vegetable peels, fallen leaves of plants, waste paper, unwanted plastic objects, glass articles, sewage etc.

4.2.1 Types of solid waste

The solid waste, that accumulate in the environment due to human activities can be categorized into two types :

(i) Bio-degradable waste
(ii) Non-biodegradable waste

Biodegradable waste : Those substances which are broken down by the activity of micro-organisms and enter the biogeo-chemical cycles. These substances can easily be degraded by natural means i.e. by action of micro-organisms (like bacteria and fungi) into simpler harmless substances in some time. Then, they reach the reservoir pool (air, water or soil). They act as pollutants only when their quantity is large and they are not degraded at the right time.

Example : Domestic waste products, faecal matter, sewage, agricultural residue, paper, wood, cloth etc.

Harmful effects of biodegradable wastes : Biodegradable substances act as pollutants only when their quantity becomes large and they are not broken down into simpler substances by the action of micro-organisms at the right time.

These affect the human life in various ways :

1. Decomposition of biodegradable wastes results in the production of foul smell which spreads to surrounding areas and makes the life miserable.
2. Flies breed at huge heaps of solid wastes containing biodegradable substances, carry the germs and spread diseases such as diarrhoea, typhoid, tuberculosis, cholera, conjunctivitis etc.
3. These biodegradable wastes may also block the drains, creating pools of water which become the breeding sites of mosquitoes. The latter are the carriers of diseases like malaria and dengue.
4. Dumping of industrial wastes reduces the fertility of the soil leading to reduction in crop yields.

Non-biodegradable waste : These substances do not break down into simpler and harmless products. These substances cannot be decomposed by microorganisms like bacteria. They are the major pollutants of the environment. They may enter into food-chain and harm the organisms.

Example : Insecticides, pesticides, DDT, mercury, lead, arsenic, aluminium, plastics, iron nails and radioactive waste.

These non-biodegradable substances may occur in the environment in gaseous, liquid or solid form.

Harmful effects of Non-biodegradable waste :

1. Some of the non-biodegradable substances such as pesticides (e.g., D.D.T.), industrial chemicals, heavy metals, and radioactive substances are very harmful. This is so because these enter the food chains and their concentration goes on increasing from one trophic level to the next. As human beings occupy the top level in any food chain, the maximum concentration of these chemicals get accumulated in our bodies. As a result of biomagnification, there are many harmful effects in human beings and other animals.
2. Excessive use of fertilizers and pesticides, and dumping of industrial chemical wastes affects the soil fertility and subsequently reduces the crop yield. The soil, thus, may become acidic or alkaline.

4.2.2 Modes of waste disposal

It means getting rid of the waste. The disposal of waste should be done in a scientific way. Before studying various methods of waste disposal, let's study an example to understand how the use of biodegradable and non-biodegradable materials can make a difference to our environment.

(i) Earlier, tea in trains was served in plastic glasses which had to be returned to the vendor. This was not hygienically correct.
(ii) So, the disposable plastic cups were introduced which could be used once and thrown away.
(iii) Though this was hygienic but the disposal of millions of plastic cups on daily basis posed a big problem.
(iv) Sometime back, kulhad's (disposable cups made of clay) were suggested as an alternative. It was, however, soon realized that the use of a lot of clay for making millions of 'kulhads' daily led to the loss of the fertile top-soil. So the practice of using 'kulhads' has also been discontinued.

Kulhads

Paper cups

(v) Now a days, paper cups are being used. This is so because paper is biodegradable.

Methods of waste disposal

Now, we will read about methods of waste disposal. They are :

(a) Sanitary land fills : The waste is pulverised and spread over a low lying area. It is compacted and covered by a layer of earth. This reduces bulk of waste, prevents release of offensive odours and spread of pathogens.

(b) Recycling of wastes : Paper, glass, polythene, plastic, metals can be recycled. Waste coming from industries such as metals can be melted and recycled into solved metal. Molten plastic waste mixed with asphalt can be used to make roads.

(c) Composting : Putrescible waste is shredded, mixed with sewage sludge and spread in open to form compost. The domestic waste can easily be converted into manure.

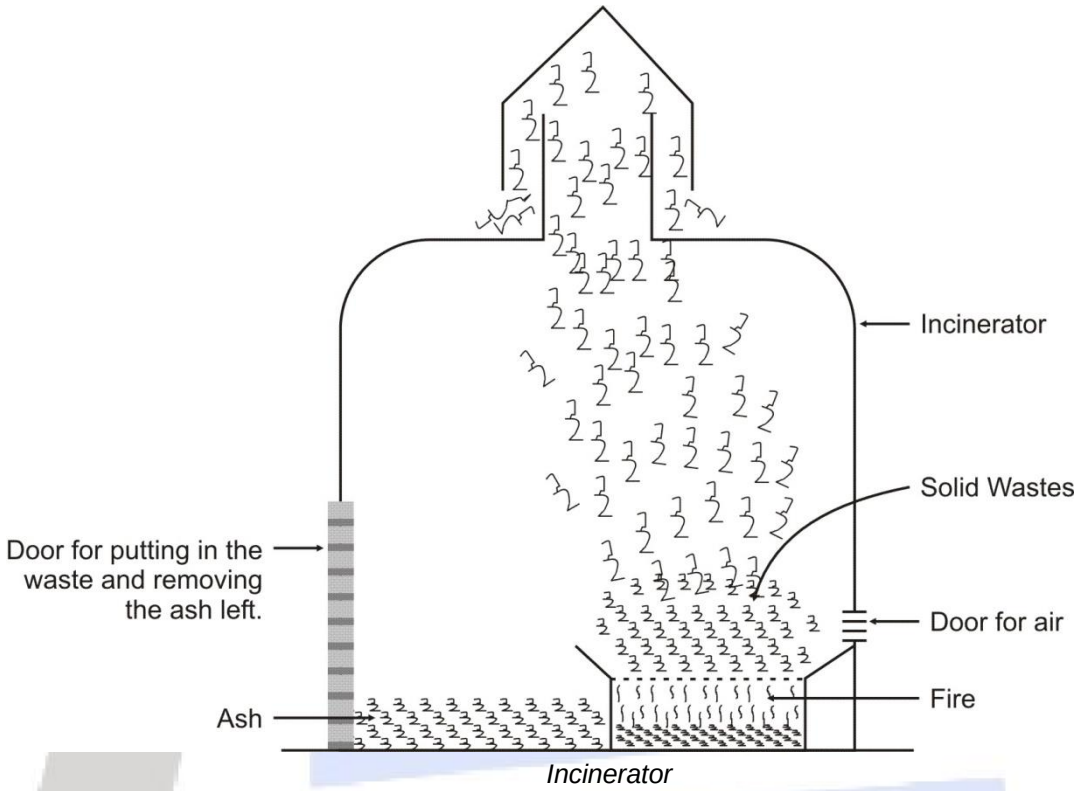
(d) Biogas and manure can be prepared from the biodegradable waste. It costs much less than other fuel and fertilizers.

(e) Salvage : Articles which can be recycled should be removed from garbage, e.g., metals, glass, plastic etc. The articles which are non-biodegradable like nails, pieces of iron, broken glass pieces should be removed from garbage.

(f) Pesticides and fertilizers : Their use should be reduced by resorting to biological control (for pests) and organic farming.

(g) Incineration or burning at high temperature : Incineration is the process of burning of substances at high temperature (usually more than 1000°C) and ultimately converting them into ashes. It is carried out in an incinerator. Household waste, chemical waste and hospital waste are generally disposed off by incineration process. In fact, **bulk of waste** is removed by this technique. Burning of waste at a very high temperature generates carbon dioxide and water vapours, which escape into the environment and only the ash is left behind.

This ash can be disposed off by land fills. In cities, municipal committees/corporations generally do large scale disposal of waste by incineration.



Incinerator