2: Ecosystems

Do you know?

Earth is perhaps the only planet in the solar system that supports life. The portion of the earth which sustains life is called biosphere. Biosphere is very huge and cannot be studied as a single entity. It is divided into many distinct functional units called ecosystems.

To understand the proper structure and functions of various kinds of ecosystem, it is very essential to understand the scope of ecology.

The word ecology is derived from two Greek words i.e. "Oikos" meaning house and "ology" means to study. Thus, ecology is the study of organisms in their natural home i.e. habitat. It is generally defined as the study of plants and animals in reciprocal relationship with their environment.

2.1 Scope of ecology:

Ecology deals with the interrelationship between the organisms and its environment. Therefore the scope of ecology becomes wide due to variable environmental conditions as well as abundance of plants and animals. The main function of ecology is to show the general principle under which the natural community and its various components operate. These may be applied for the interpretation of various activities of particular plants or the animals in a given region. The biota (plants and animals) of an area can be easily identified and counted. An understanding of ecology is useful for conservation of air, water, soil, wildlife etc. Ecology has practical applications in the field of agriculture, biological survey, forestry and fisheries.

In this lesson, you will study about the structure, types and functions of ecosystems.

2.2 Structure and function of Ecosystems:

In nature several communities of organisms live together and interact with each other as well as with their physical environment as an ecological unit. An ecosystem is a functional unit of nature encompassing complex interaction between its biotic (living) and abiotic (non-living) components. For example- aquatic systems such as a pond, lake, river, estuary, ocean. The terrestrial ecosystems includes forest, grassland, agricultural field, desert etc.

The structure of ecosystem is includes two kinds of components.

(a) Abiotic components

(b) Biotic components

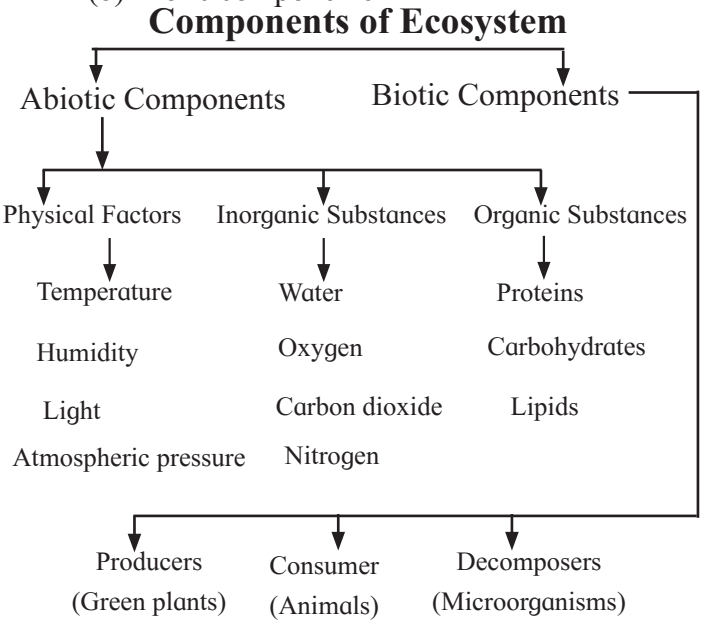

Figure 2.1 : Components of Ecosystems

(a) Abiotic components (Non-living):

The abiotic component can be grouped into following three categories:-

(i) Physical factors: Sunlight, temperature, rainfall, humidity and pressure. They sustain and limit the growth of organisms in an ecosystem.

(ii) Inorganic substances: Carbon dioxide, nitrogen, oxygen, phosphorus, sulphur, water, rock, soil and other minerals.

(iii) Organic compounds: Carbohydrates, proteins, lipids. They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components.

(b) Biotic components (Living)

(i) Producers: The green plants manufacture food for the entire ecosystem through the process of photosynthesis. Green plants are called autotrophs, as they absorb water and nutrients from the soil, carbon dioxide from the air, and capture solar energy for this process.

(ii) Consumers: They are called heterotrophs and they consume food synthesized by the autotrophs. Based on food preferences they can be grouped into three broad categories.

a) Herbivores feed directly on plants (e.g. cow, deer and rabbit etc.)

b) Carnivores are animals which eat other animals. (eg. lion, cat, dog etc.)

c) Omnivores organisms feed upon both plants and animals (e.g. human beings, pigs and crows).

(iii) Decomposers: Also called saprotrophs. These are mostly bacteria and fungi that feed on dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. They play a very important role in recycling of nutrients. They are also called detritivoours or detritus feeders.

Functions of ecosystems :

Ecosystems are complex dynamic entities which include abiotic and biotic components. They perform various functions. These are:-

(i) Energy flow through food chain

(ii) Nutrient cycling (biogeochemical cycles)

(iii) Ecological succession or ecosystem development

Ponds, lakes, marshlands, grasslands, deserts and forests are examples of natural ecosystems. Many of you have seen a aquarium, a garden and an agricultural field in your neighborhood. These are examples of man made ecosystems.

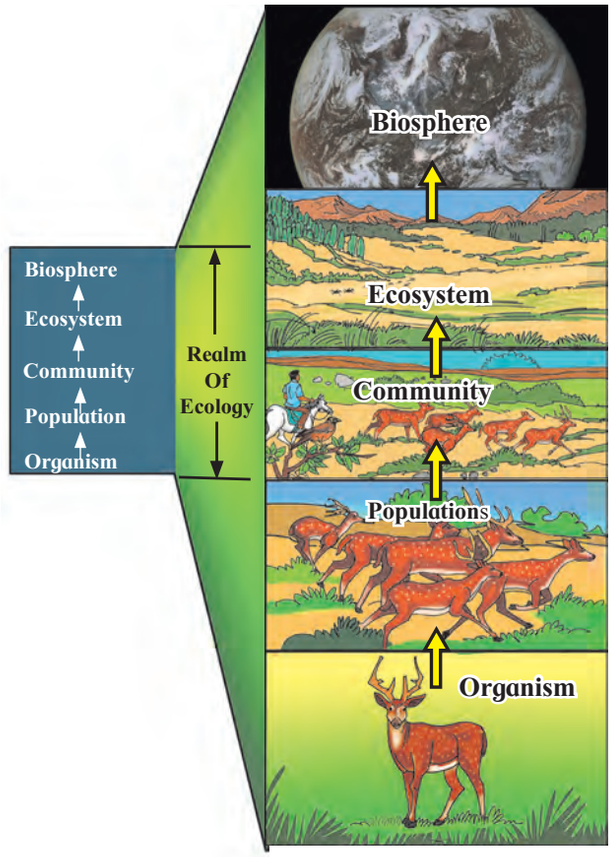

Figure 2.2 : Realms of Ecology

2.3 Types of ecosystems

Ecosystems are broadly classified as follows:

(I) Natural ecosystems

(II) Man made ecosystems

(I) Natural ecosystems

Natural ecosystem are totally dependent on solar radiation e.g. forests, grasslands, oceans,

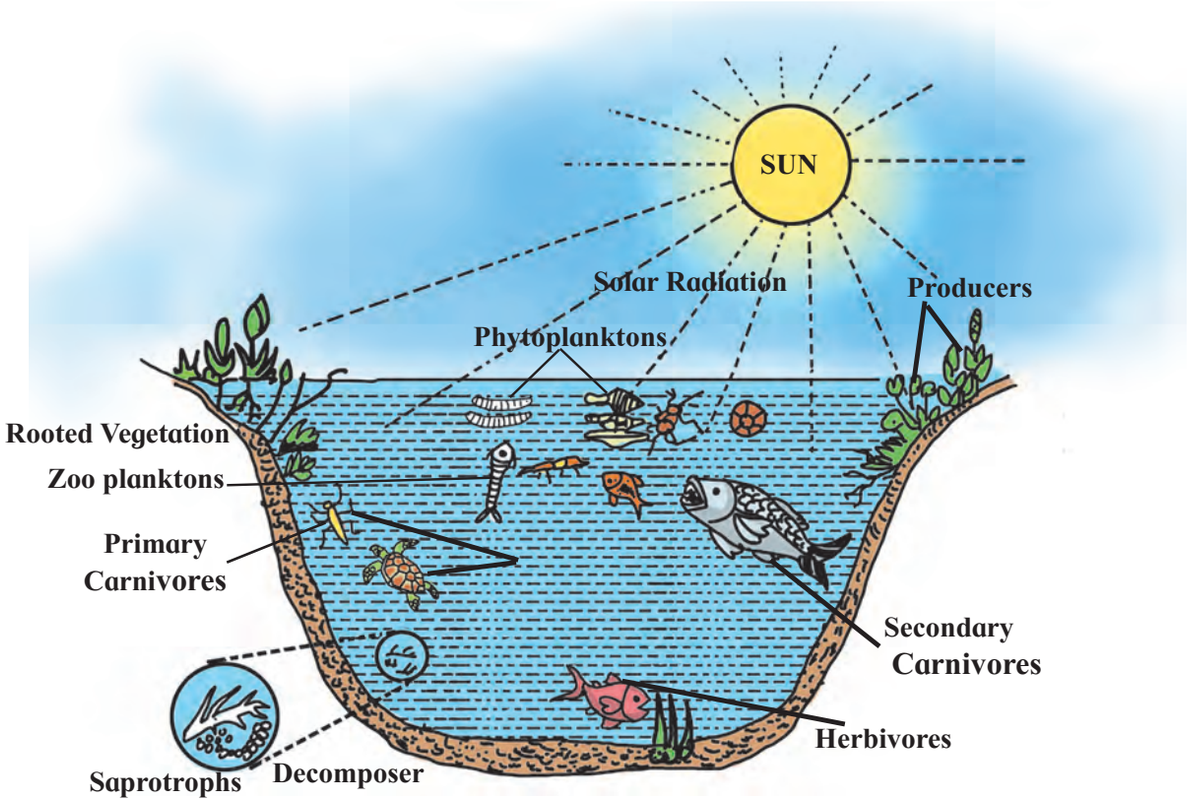

Figure 2.3 : Pond ecosystem

lakes, rivers and deserts. They provide food, fuel, fodder and medicines.

Pond Ecosystem:

A pond is an example of natural ecosystem. It is convenient to study its basic structure and functions. It works on solar energy and maintains its biotic community depending on the seasons. If you collect a glass full of pond water or a scoop full of mud from bottom of the pond, it consists of a mixture of plants, animals, microorganisms, inorganic and organic materials.

The Following components are found in a pond ecosystem.

(a) Abiotic (Non-living) components of pond ecosystem:

(i) Sunlight: Solar radiation provides energy that controls the entire system. Penetration of light depends on transparency of water, amount of dissolved or suspended particles in water and the number of plankton. On the basis of extent of penetration of light a pond can be divided into euphotic(eu=true, photic = light), mesophotic and aphotic zones.Plenty of light is available to plants and animals in euphotic zone. No light is available in the aphotic zone.

(ii) Inorganic substances: These are water, carbon, nitrogen, phosphorus, calcium and a few other elements like sulphur depending on the location of the pond. O_2 and CO_2 are in dissolved state in water. All plants and animals depend on food and exchange of gases in the water. Other inorganic salts are held in reserve in bottom sediment and inside the living organisms.

(iii) Organic compounds: The commonly found organic matter in the pond area are amino acids, humic acids and the breakdown products of dead animals and plants. They are partly dissolved in water and partly suspended in water.

(b) Biotic (Living) components of pond ecosysytem

(1) Producers or autotrophs :

Synthesize food for all the heterotrophs of the pond. They can be categorized into two groups:-

(a) Floating microorganisms and plants

(b) Rooted plants

(a) Floating microorganisms: Small green plants (algae) and blue green algae are called phytoplanktons ("phyto"- plants, "plankton"– floating). They are microscopic organisms. Sometimes they are so abundant in pond that they impart green colour to pond water. *Spirogyra, Ulothrix, Cladophora, Diatoms, Volvox*.

(b) Rooted plants: These are arranged in concentric zones from periphery to the deeper layers. Three distinct zones of aquatic plants can be seen with increasing depth of water in the following order:

i) **Zone of emergent vegetation:** e.g. *Typha* and *Sagittaria*

ii) **Zone of rooted vegetation with floating leaves** .eg. *Nymphaea*

iii) **Zone of submergent vegetation:** eg. All under water vegetation like *Hydrilla, Vallisnaria* etc.

(2) Consumers (Heterotrophs) : These are the animals which feed directly or indirectly on autotrophs eg. Tadpole, snails, some variety of fish.

Pond animals can be classified into the following groups

(a) *Zooplanktons are floating animals. Cyclops, Cypris, Daphnia* etc.

(b) Nektons are the animals that can swim and navigate eg. fishes

(c) Benthic animals are the bottom dwellers e.g. beetle, mites, molluscs and some crustaceans.

(3) Decomposers: They are distributed throughout the pond, but are most abundant in the sediment. There are bacteria and fungi. (*Rhizopus, Penicillium, Cladosporium*) found at the bottom of the pond.

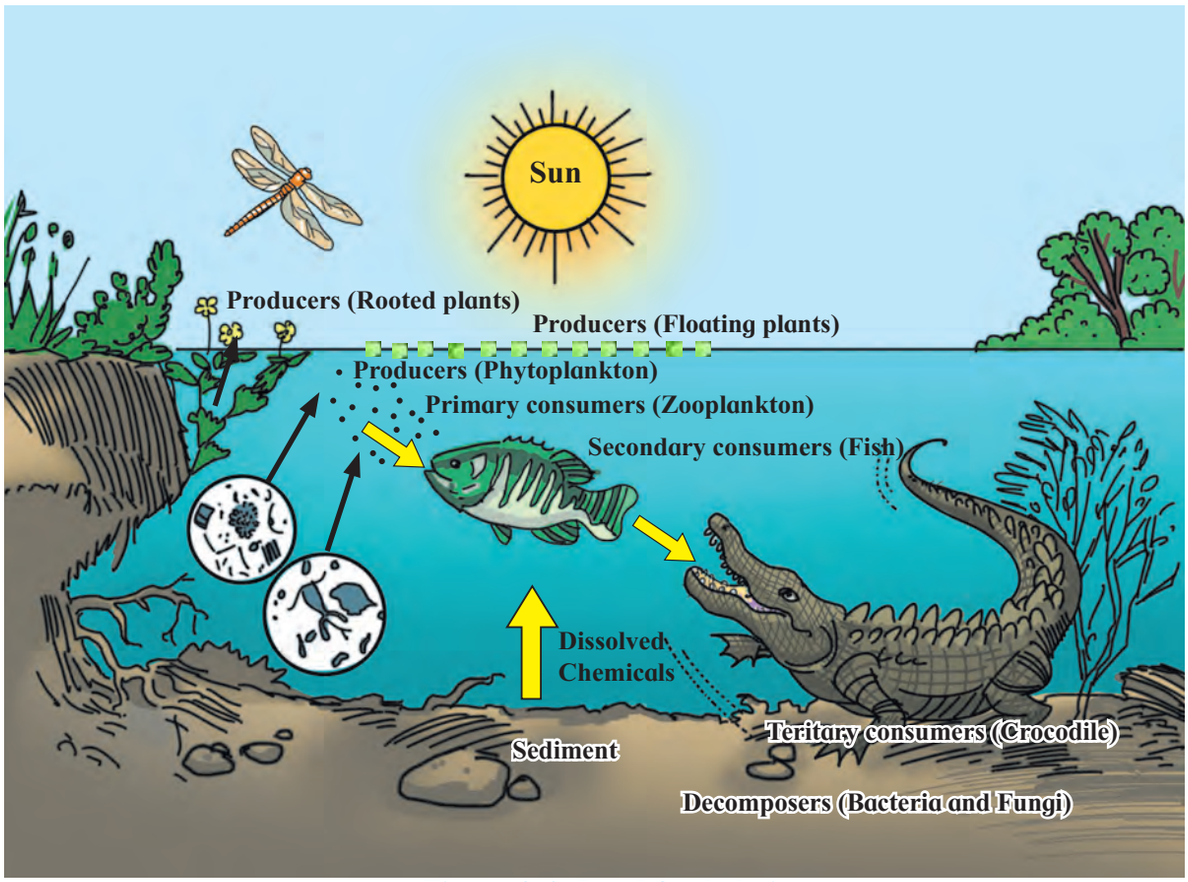

Figure 2.4: Pond food chain

(II) Man made ecosystems:

1) It is a system which is influenced by significant human interactions between living and non living components.
2) They do not possess self regulating mechanisms.
3) The cycling of nutrients is negligible.
4) The inputs are provided by human efforts.

Examples are crop fields and orchards.

Activity 1:
Visit a local pond near your locality and make the list of following:

(1) Note down the colour of pond water.

(2) Check pH value of pond water with pH paper.

(3) Make list of number of different types of plants and animals observed in the water.

Activity 2 :
Observe a park of your locality before and after the rains for one month and record your observations (count the number of different birds, plants and insects).

2.4 Dynamics of ecosystems

In the ecosystems, the flow of energy and matter from one component to the other component is called its dynamics. It is also called as functions of the ecosystems. The nutrients and minerals work through cycles between the biotic and abiotic components of the ecosystem. The energy transfer in the ecosystem is unidirectional and it never returns back to the source (i.e. sun).

The dynamics of ecosystem can be explained under the following heads-

1) Food chain
2) Food web
3) Trophic levels
4) Energy flow
5) Ecological pyramids
6) Bio-geochemical cycles.

1. Food chain : The transfer of food energy from the source (Producers / green plants) to consumers forms a food chain. Green plants in the food chain occupy the first trophic level (i.e. producer).The herbivores that eat the plants occupy second trophic level (i.e. primary consumers). The carnivores that eat the herbivores occupy third trophic level (i.e. secondary consumers) and occasionally even a fourth trophic level (i.e. tertiary consumer).

In nature three types of food chains have been distinguished namely grazing food chain, parasitic food chain and detritus food chain.

I) Grazing food chain: This food chain starts from green plants, goes through herbivores and terminates in carnivores.

The photosynthetic organisms, synthesise their food from inorganic elements in the presence of sunlight, hence they are called producers.The producers are eaten by herbivorous animals, thus herbivorous animals are called primary consumers. Primary consumers or herbivores are eaten by secondary consumers called carnivores. Thus this type of food chain depends on autotrophs as primary producer.

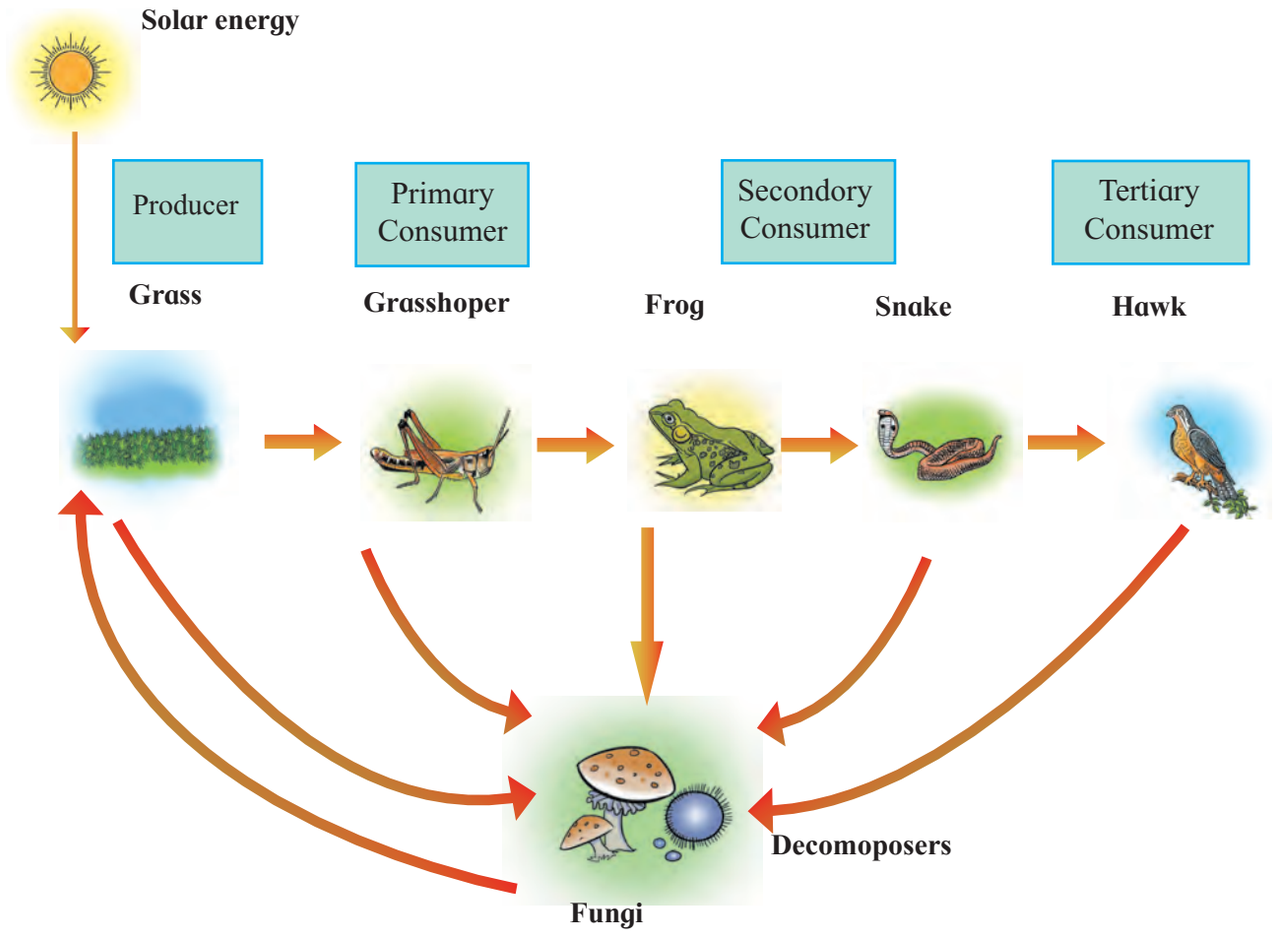

Figure 2.5 : Food Chain

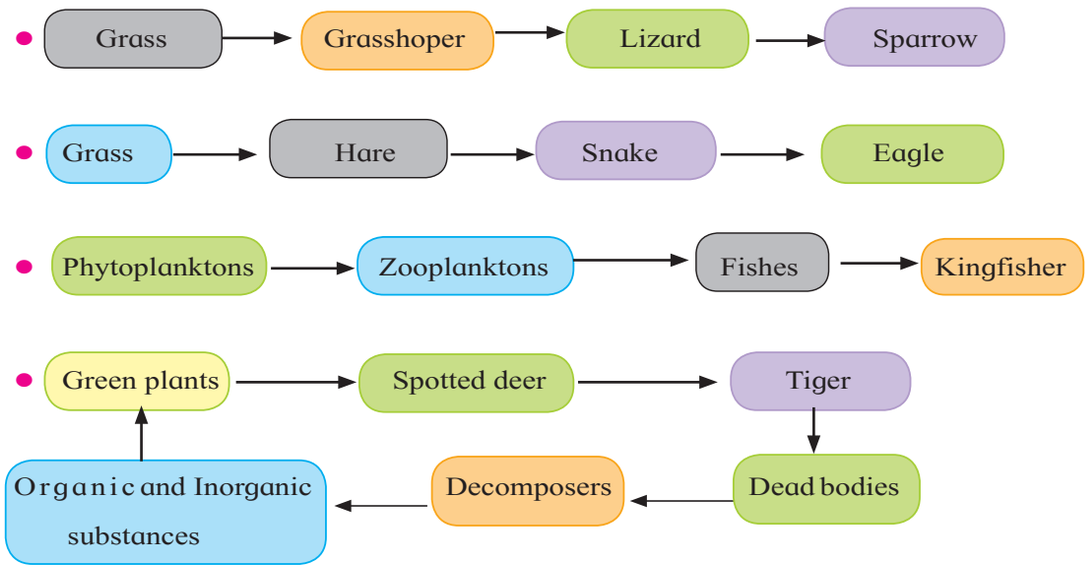

Figure 2.6: Food chains in different ecosystems

II) Parasitic food chain: This food chain goes from large organisms to smaller ones without killing the host organism. For e.g. large number of lice live on herbivore as ectoparasites.

III)Detritus food chain: The food chain starts from dead organic matter of decaying plants and/or animals bodies, microorganisms and then to detritus feeding organisms (detritivores or saprovores) and their predators this is known as detritus food chain. Dead and drying leaves in forest are broken into smaller pieces by soil animals such as beetles, ants, earth warms on which fungi and bacteria act to produce soil nutrients. some of these soil animals are used as food by secondary consumers like birds, frogs and lizards.

This type of interrelationship interlinks the individuals of the whole community. In this way multiple food chains become interlinked forming a food web. The food web maintains the stability of the ecosystem.

Energy flow in ecosystem :

Energy can be defined as the capacity to perform work. The solar radiation is the primary source of energy for all organisms which passes through the different trophic levels. Organisms that can fix energy from inorganic sources into organic molecules are called autotrophs. Organisms that cannot obtain energy from abiotic sources but depend on energy-rich organic molecules which is synthesized by autotrophs are called heterotrophs. Those organisms that obtain energy from living

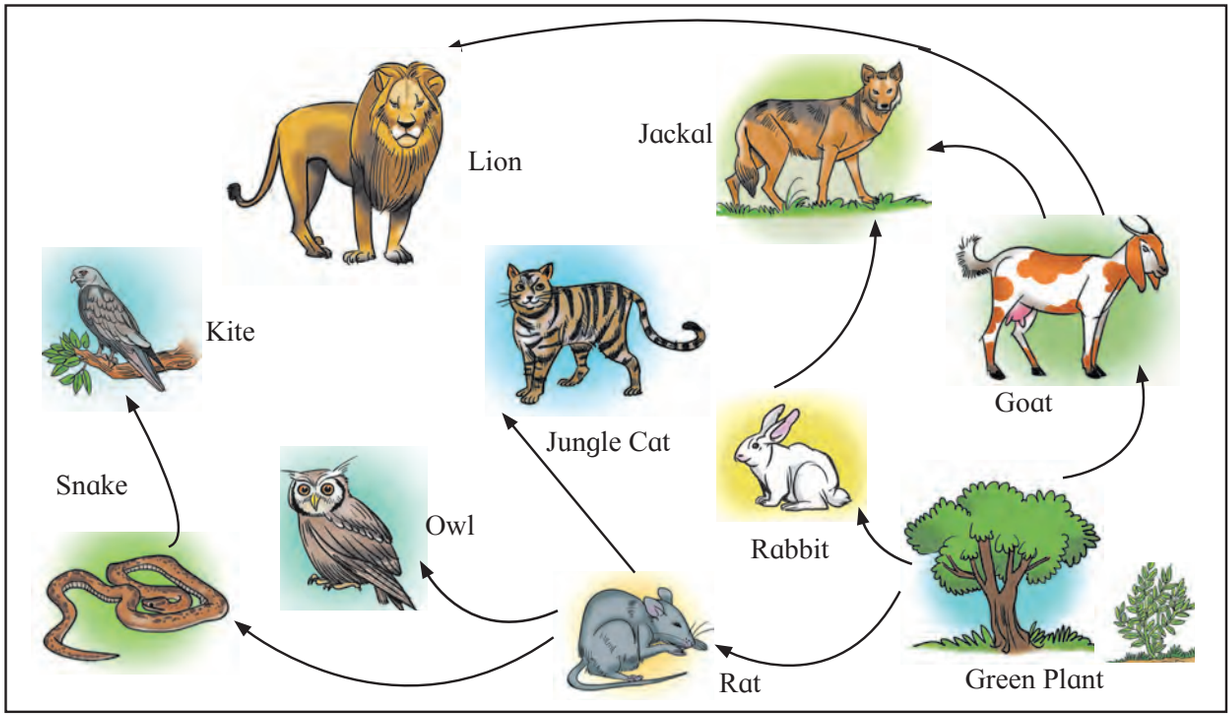

Figure 2.7 : Food Web

2. Food Web: Many food chains exist in an ecosystem, but these food chains are not independent of each other. The producers are eaten by variety of insects, birds, mammals and fishes. These first order consumers are eaten by predators. In grassland ecosystem, grass is eaten by herbivores such as hare which will be eaten by snake, which will be eaten by an eagle.

organisms are called consumer and those that obtain energy from dead organisms are called decomposers.

The movement of energy in an ecosystem is termed as the energy flow in nature.

i) The producers absorb and convert solar energy into plant material.

ii) The energy converted into biomass is used by consumers.

iii) The total input of energy in form of food is used for day to day activities and biomass.
iv) The loss of energy occur through respiration, heat, excretion.
v) The gross net production.

About 23% of incoming solar energy is absorbed in the atmosphere by water vapours, dust and ozone, and 48% passes through the atmosphere and is absorbed by the surface. Thus about 71 % of the total incoming solar energy is absorbed by the earth system. However plants do not absorbs all incoming sunlight and do not convert all harvested energy into biomass, which results in an overall photosynthetic efficiency of 3 to 6 % of total solar radiation. It means very small amount of sunlight reaching the earth's atmosphere is used in photosynthesis. The plant synthesize food in the form of carbohydrates i.e. is a form of chemical energy. This chemical energy of carbohydrates is used as a food for herbivores. In the food chain or food web, there is transfer of both the matter and energy in the living world.

The transfer of energy is never 100 %. The green plants trap solar energy and convert it into chemical energy, they are the producers. They use some amount of energy for their own life processes. Therefore, only a small portion of the energy trapped by the producers is available to primary consumers. Animals move from place to place, so they require more energy. Therefore they transfer less amount of energy to the next trophic level.

At every trophic level, a considerable amount of energy is lost to the surroundings in the form of heat. The amount of energy available to the next higher level is only 10%.

Even decomposition of organic matter carried out by microbes is responsible for release of heat energy. Thus most of the solar energy trapped by the green plants goes to the atmosphere in the form of heat. But, this heat energy never returns to the sun. Energy transfer is therefore never in the reverse direction.

Ecological pyramids

Ecological pyramids are the graphic representations of trophic levels in an ecosystem. The producers make the base of the pyramid and the subsequent tiers of the pyramid represent herbivore, carnivore and top carnivore. The pyramids are of three types.

(1) Pyramid of number:

This represents the number of organisms at each trophic level.

For example in a grassland the number of grasses is more than the number of herbivores that feed on them and the number of herbivores is more than the number of carnivores.

In some instances the pyramid of number may be inverted, i.e herbivores are more than primary producers as you may observe that many caterpillars and insects feed on a single tree.

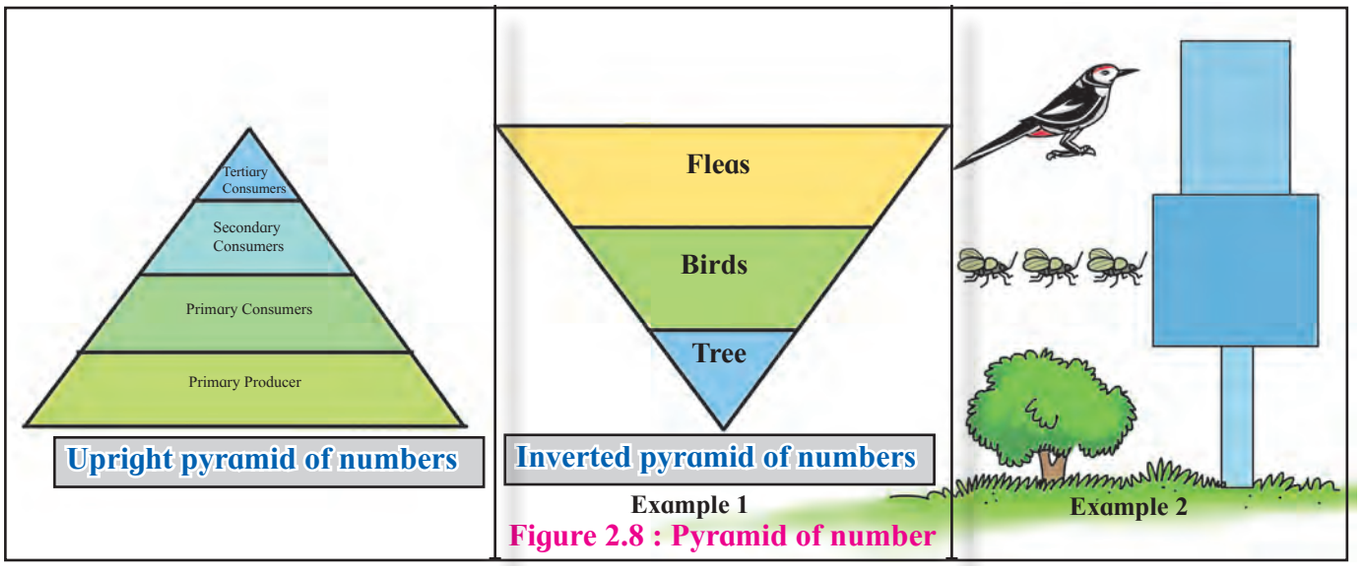

Figure 2.8 : Pyramid of number

(2) Pyramid of biomass:

This represents the biomass at each trophic level. Standing biomass is the amount of the living matter at any given time. It is expressed as gm/unit area or kilo cal/unit area. In most of the terrestrial ecosystems the pyramid of biomass is upright. However, in case of aquatic ecosystems the pyramid of biomass may be inverted e.g. in a pond, phytoplankton are the main producers, they have very short life cycles and a rapid turn over rate (i.e. they are rapidly replaced by new plants). Therefore, their total biomass at any given time is less than the biomass of herbivores supported by them.

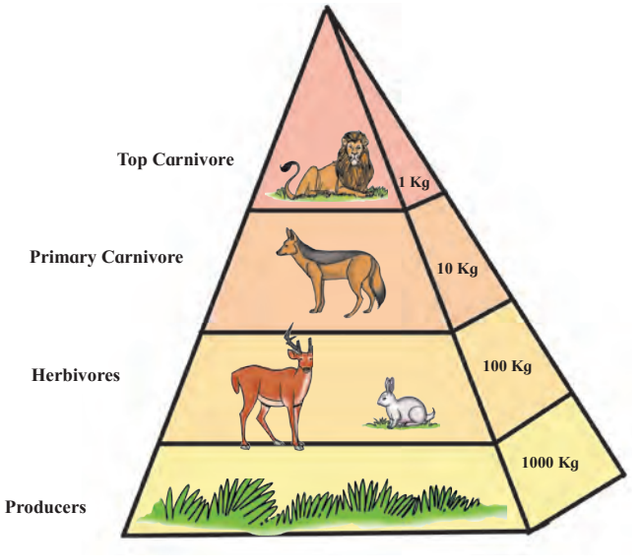

Figure 2.9 : Upright Pyramid of biomass in Terristrial Ecosystem

(3) Pyramid of energy :

This pyramid represents the total amount of energy at each trophic level. Energy is expressed in terms of kcal/unit area /unit time. Energy pyramids is never inverted.

All the living organisms of an ecosystem are interdependent through food chains and food webs. Removal of any single species of the community causes ecological change.

In the food chain the producers can be eaten by several primary consumers (herbivoves). These multiple herbivoves are eaten by only a fewer species of carnivares. In every ecosystem the quantum of producers is the largest followed by primary consumers and only a few second order consumers. This is because at every step in the trophic chain energy is lost in day to day activities.

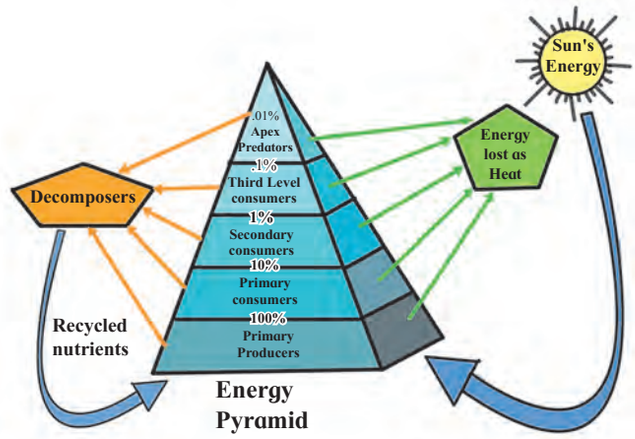

Figure 2.10 : Pyramid of Energy

Biogeochemical cycle

The nutrients move from the nonliving to the living and back to the nonliving component of the ecosystem in a more or less circular manner is known as biogeochemical cycle.

After the death of organisms, the dead remains are decomposed and the nutrients are released back into the soil by detrivores. These are absorbed again by the root of green plants and are passed on to herbivores and then to the carnivores. Micro organisms and fungi play a role in the recycling of nutrients. This recycling of the nutrients is called biogeochemical or nutrient cycle. There are more than 40 elements required for the various life processes by plants and animals. The entire earth or biosphere is a closed system i.e. nutrients are neither imported nor exported from the biosphere.

The common biogeochemical cycles are.

1. Nitrogen cycle
2. Carbon cycle
3. Oxygen cycle
4. Sulphur cycle
5. Phosphorous cycle
6. Hydrological cycle (Water cycle)

2.5 Ecosystem services

Ecosystem services can be devided into resources used by people and services of nature. examples

Direct uses of forest ecosystem resources

- Timber
- Fruits
- Tubers
- Medicine
- Fuel woods

Indirect values of forest ecosystem :

1. Regulating Ecological balance
2. Conservation of water and soil
3. Maintain temperature
4. Increase rainfall rate
5. Habitat for wild animals
6. Increase asthetic value of nature

Ecosystem services are processes in natural ecosystems which sustain biodiversity and human needs. Nature provides these services to us free of cost. Ecosystem services have both ecological and economic values. But in recent decades, however, they have been seriously affected by human activities.

Ecosystem services provide us in many ways:

a) **Provisioning services:** It includes all products that are collected by people which include food items like fruits, tubers, herbs, and medicinal plants. People depend on forest ecosystem for fuel wood, fodder, building material for housing etc. The forest products are of great economic value as they are collected and marketed.

Various industrial products are being produced from the wild plants of the forest. Many of our medicines come from wild plants from different ecosystem.

b) **Supporting services:** The other supporting services provided by ecosystem are biomass production, production of atmospheric oxygen, soil formation etc. Forest indirect services include the control of flow of water in streams and rivers. Forest cover reduces the surface run-off of rain water and allows the recharge of ground water. Forest also prevents the erosion of soil which takes thousands of years to form.

c) **Regulating services:** The regulation of ecosystem process, includes, the flood control, regulation of climate, water purification, control of human diseases etc. Forest regulates the local temperature by absorbing carbon dioxide and release the oxygen that we breathe. And also it helps to maintain temperature and moisture. It also maintains the ecological balance, habitat for wild animals and increase rate of rainfall.

d) **Cultural services:** There are various non-material benefits which people obtain from ecosystems like education, recreation and various cultural practices.

2.6 Species interdependence and interactions

Different species in an ecosystem have common activities or resource needs. They may interact with one another of the same species or with the individuals of the other species. Such interactions may benefit a species or may cause harm to it or may not affect it in any way.

There are some basic types of interdependence and interaction between species

1) Competition
2) Predation
3) Parasitism
4) Mutualism
5) Commensalism

1) Competition: Competition between individuals occurs when resources such as food and space are shared. Individuals may compete with members of their own species (Intraspecific competition) or with members of other species who use the same resources (Interspecific competition).

For example - a) Plants compete with one another for access to light and water.

b) Various animals compete for food and space.

Figure 2.11 : Competition

2) Predation: Predation is an interaction between species in which one species (the predator) kills and eats another species (prey).

Example : in the following figure Lion is predator and Deer is the prey.

Figure 2. 12 : Predation

3) Parasitism: Parasitism is a relationship in which one organism (the parasite) benefits at the cost of another organism (the host).

Example:

a) Ticks on the skin of a dog.

b) *Cuscuta* plant as a parasite on a host plant

Figure 2.13 a : Ticks on the skin of a dog

Figure 2. 13 b : Cuscuta plant as a parasite on a host plant

4) Mutualism: Two organisms interact in such a way that both benefits from the relationship from each other.

Example: Lichens which are formed as a result of a association between fungus and algae. The fungi provide home for the algae and the algae provides food.

Figure 2.14 : Mutualism (Lichen)

5) **Commensalism:** Commensalism is an interaction between two species in which one is benefited, but the other is neither benefited nor harmed.

Example: Epiphytic plants like Orchids (Vanda) attaching themselves on trees just for support but not for nutrition.

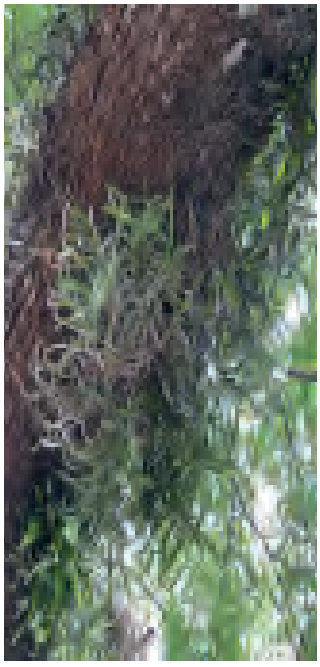

Figure 2.15 : Epiphytic plant *Vanda*

2.7 Ecological Succession

Vegetation occupying a given habitat under natural condition is called as a plant community. The gradual replacement of one type of plant community by others is called as plant succession.

Succession is a complex process which begins, develops and finally stabilizes at the climax stage. The climax stage is the final, self maintaining, mature and self reproducing stage of vegetational development in a climatic unit.

Kinds of Succession

On the basis of different aspects, succession can be classified into several categories. They are discussed as follows.

On the basis of presence or absence of vegetation in the area where succession takes place, it is divided into two kinds. They are primary succession and secondary succession.

a) **Primary succession:** If the succession starts on the extreme bare area on which there was no previous existence of vegetation such as newly exposed rocks, surface of lava flow etc. are known as primary succession. The first group of organisms that establish themselves on bare areas are known as pioneers or primary colonizers.

b) **Secondary succession:** If succession starts on a place which was once occupied by plant communities that has changed by natural or manmade alteration the process is secondary. Destructive agencies like fire, cultivation, strong wind, soil erosion, draught, rain are responsible for denudation process. The bare area formed after denudation process is known as secondary bare area. Secondary succession is more rapid than the primary succession.

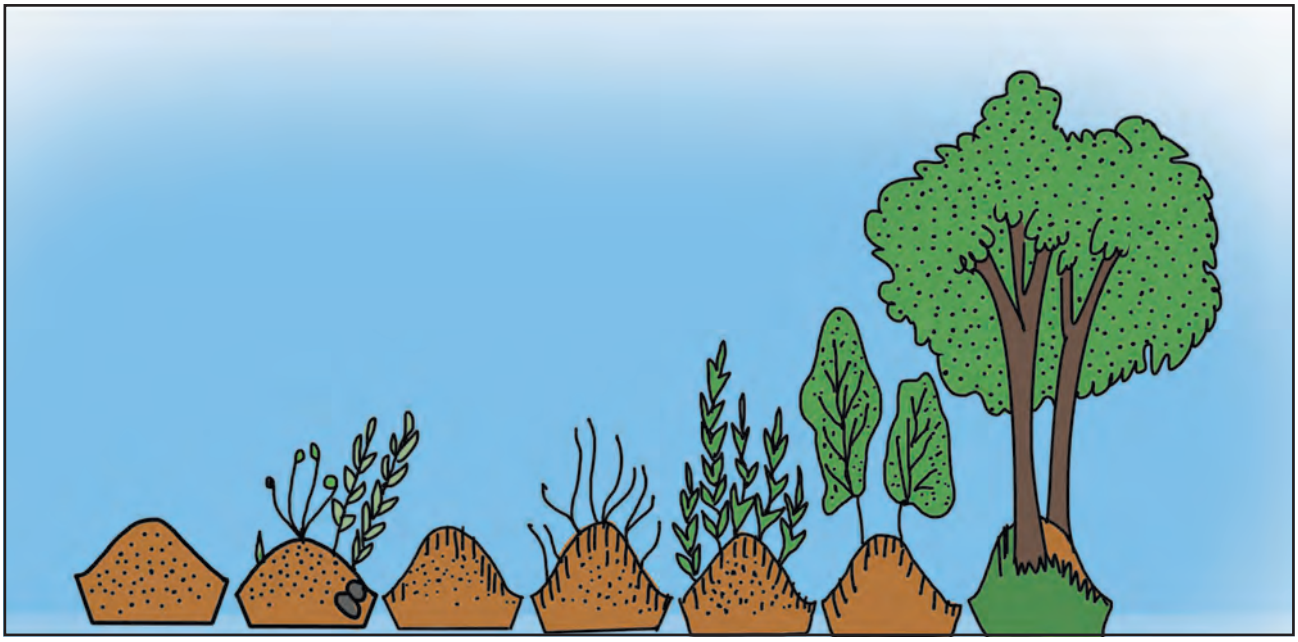

Figure 2.16 : Ecological Succession from virgin land to climax

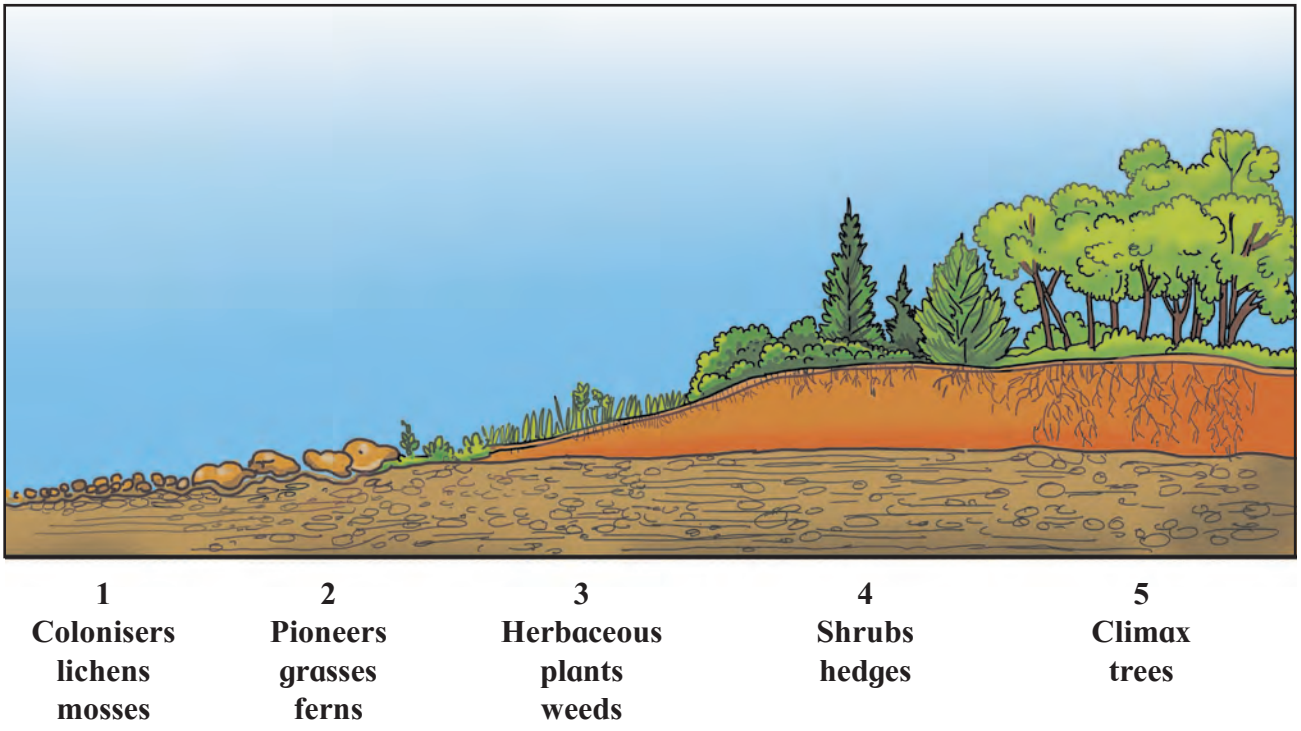

Figure 2.17 : Ecological Succession

Exercise

Q.1. Multiple choice questions.

1. The word Ecology is derived from the ……. word.
   a. American c. Greek
   b. Latin d. None of above
2. Sunlight is ……. type of component
   a. Abiotic c. Biotic
   b. Both a & b d. None of these
3. ……. is not a member of aquatic ecosystem
   a. Tiger c. Fish
   b. Algae d. Aquatic plants
4. Source of energy for green plants is …….
   a. Earth c. Moon
   b. Sun d. Air
5. ……. is not an example of indirect use of ecosystem services
   a. Regulation of ecological balance
   b. Conservation of water and soil
   c. Habitat for wild animal
   d. Fuel wood
6. Organisms that can fix energy from inorganic sources into organic molecule are called …….
   a. Autotrophs c. Hetrotrophs
   b. Decomposersd. d. Consumers
7. Lichen is an example of ..... .
   a. Predation b. Parasitism
   c. Mutualism d. Commensalism
8. ..... is not an example of carnivore
   a. Rabbit b. Lion
   c. Fox d. Vulture

Q.2. Write the answers in short of the following.

1) What is ecosystem?
2) What are the indirect uses of ecosystem?
3) Define food web and Explain it.
4) What is standing crop biomass?
5) Name different biogeochemical cycles.
6) Give two ecosystem services provided by forest.
7) What is parasitism?
8) What is predation?
9) What is primary succession?

Q.3. Long answer questions.

1) Explain structure of ecosystem.
2) Explain pond ecosystem.
3) What is ecological pyramid? Explain pyramid of number.
4) Explain energy flow in ecosystem.
5) Explain in detail ecosystem services.
6) What is succession? Explain kinds of succession.