1. Introduction to Ecology

The term ***Ecology*** is derived from two Greek words, namely ***Oikos*** and ***Logos.*** ***Oikos*** means ***'home'*** or ***'habitation'*** or ***'a place to live in'***. ***Logos*** means ***'study'*** or ***'discourse'***. Hence literally speaking, ***Ecology*** is the study of ***organisms at home.***

Ecology is defined by ***Odum*** (1969) as *'the study of the inter-relationships between organisms and environment'.*

According to ***Kendeigh*** (1961) Ecology is *'the study of animals and plants in their relations to each other and to their environment'.*

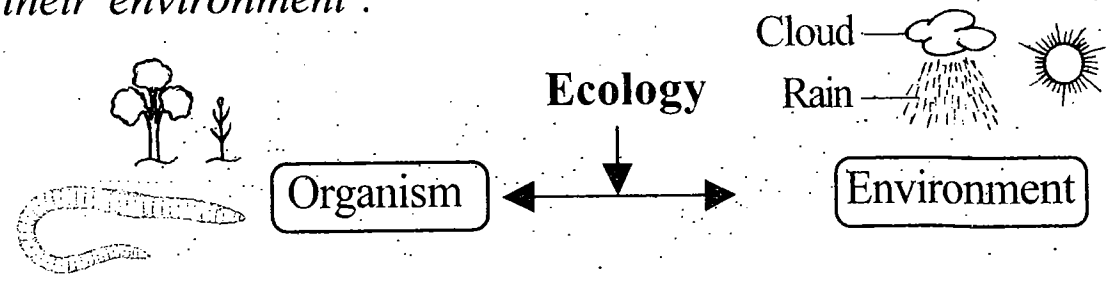


Fig.1.1: Ecology, study of organisms in relation to their environment.

Warming (1905) defined Ecology as *'the study of organisms in relation to their environment'.*

According to ***Taylor*** (1936) Ecology is *'the science of the relations of all organisms in relation to all their environment'.*

According to ***Haeckel*** (1869) Ecology is *'the total relations of animals to both its organic and inorganic environment'.*

In ancient times, the branch of ***Ecology*** was named by many other terms. In 1859, ***Hilaire*** coined the term ***Ethology*** for Ecol-

ogy. ***Mivart*** coined the term ***Hexicology.*** In 1868, ***Reiter*** coined the term ***Oekologie.***

In modern days, Ecology is described in the name of ***Environmental Biology*** because it deals with organisms in relation to their environment. The organisms include animals and plants. The environment includes the surroundings of animals. Eg. *Soil, water, air, sunlight, rock and other organisms,* etc.

Sub-divisions of Ecology

Kirchner and ***Schroter*** (1902) broadly divided Ecology into two main sub-divisions, namely ***autecology*** and ***synecology.***

1. Autecology

This term was coined by ***Kirchner*** and ***Schroter*** (1902). It deals with the *study of individual organisms* or *individual species in relation to environment.* It includes the study of life history, behaviour, home-range, population dynamics, etc.

Autecology has great significance in economic biology such as fish culture, prawn culture, pearl culture, apiculture, sericulture, poultry, dairy, agriculture, horticulture, silviculture, forestry, etc. It is also important for soil conservation and wild life conservation. Autecology is experimental and inductive.

2. Synecology

This term was coined by ***Kirchner*** and ***Schroter*** (1902). It deals with the *study of groups of organisms, which are associated together as a unit, in relation to environment.*

It includes the study of community and ecosystem. It deals with the study of caves, deserts, deep sea system, intertidal rocky shores, pond ecosystem, etc. Synecology is philosophical and deductive. Synecology is largely descriptive.

Both ***autecology*** and ***synecology*** are studied together. According to ***Herreid*** (1977) *the synecologist paints the outline of a picture with a broad brush and an autecologist paints the finer details.*

Branches of Ecology

Ecology is divided into many branches. They are

1. Animal Ecology

It deals with the ecological study of animals in relation to their environment.

2. Plant Ecology

It deals with the ecological study of plants in relation to their environment.

3. Habitat Ecology

It deals with the study of habitats.

4. Marine Ecology

It deals with the study of marine habitat.

5. Freshwater Ecology

It deals with the study of freshwater habitat.

6. Terrestrial Ecology

It deals with the study of terrestrial habitat.

7. Population Ecology

It deals with the study of populations.

8. Community Ecology

It deals with the study of communities.

9. Applied Ecology

It deals with the application of ecological concepts to human needs.

10. Palaeo Ecology

It deals with the study of environmental conditions and organisms of past ages.

11. Space Ecology

It deals with the trip to neighbouring planets.

12. Radiation Ecology

It deals with the study of effects of radiation and radioactive substances and their applications.

13. Human Ecology

It is the study concerned with the environment of man.

Volcanoes
Floods

16. Man made calamities :
Atomic bomb explosion
Atomic bomb testing

Scope of Ecology

Ecology provides the following scopes:

1. Maintenance of Natural Resources

Ecology provides knowledge for the proper maintenance of natural resources.

2. Control of Pollution

It helps to control the environmental pollution.

3. New Sources of Food

It helps to discover new sources of food.

4. Human Welfare

The study of the composition and ecological factors of habitats helps to determine their utility for mankind.

5. Evolution

Ecological study provides possibilities to detect and to measure the rate of ***Evolution*** in wild population.

6. Genetics

Wild organisms are a reservoir of rare genetic materials. Ecological studies help to bring these rare genetic materials to domestic animals.

7. Survival of Human Race

The promise and threat of atomic energy as well as human population explosion in the present century have pressurized the study of Ecology. Population explosion has led man to encroach upon otherwise unsuitable habitats. Safe disposal of radioactive waste materials is a problem. All these involve ecological principles. Hence a full knowledge of Ecology is necessary for the survival of human race.

7. Light

Light is the most important and indispensable ***physico-chemical, abiotic, ecological factor*** without which life cannot exist. All plants depend on light for their energy and all animals depend on plants and so without light there is no life. Hence it is called ***environmental triggers***. It functions as a limiting factor on the distribution and the varied activities of plants and animals.

Sources of Light

Organisms get light from the Sun, the moon, stars, lightning, volcanoes and bioluminescent organisms. Among these the Sun is the most important source.

Spectral Composition

Sunlight is formed of ***electromagnetic waves.*** It is formed of cosmic rays, gamma rays, X-rays, ultraviolet rays, visible lights, infrared rays, radar waves, radio waves, etc. Of these, three kinds of radiations, namely ultraviolet light, visible light and infrared rays are biologically significant.

The visible light has a wavelength range between 390 milli micron (10,000,000 milli microns = 1 cm) and 700 milli micron. The ultraviolet light has a wavelength which is less than 390 milli micron and the infrared rays have a wavelength which is higher than 700 milli micron. The visible light is formed of 7 colours, namely ***'vibgyor'*** and all these colours constitute a ***visible spectrum***. Each colour of the spectrum has a particular wavelength with blue light having lower wavelength and red light having higher wavelength.

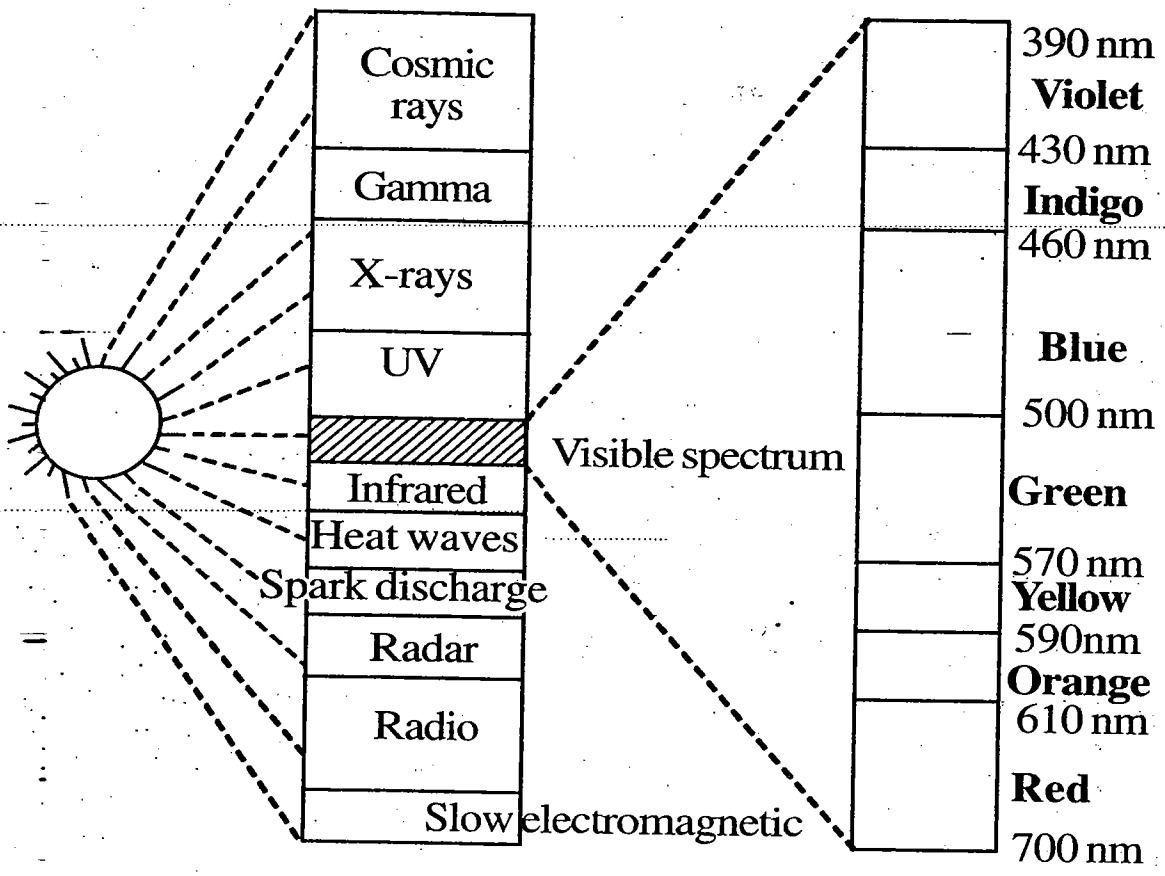


Fig.7.1: Electromagnetic spectrum.

Light is a form of energy called ***radiant energy***. The main source of energy for ecosystem is the light energy derived from the Sun. The amount of solar radiation reaching the surface of the Earth is 2 cals/sq.cm/min. It is more or less constant and is called ***solar constant*** or ***solar flux***. About 25% to 99% of the energy is lost by reflection. The plants utilize only 0.02% of the light reaching the Earth. It is converted into chemical energy in the form of sugar by photosynthesis.

Light Intensity

The intensity of light reaching the Earth's surface varies from place to place and time to time. It is controlled by a number of factors such as the following :

1. The ***angle of incidence*** of the light rays determines the intensity of light. The intensity is high when the Sun is overhead. It is low at dawn and dusk.

2. The intensity is affected by the absorption of light by gas and other particles present in the air. The light rays having wavelength shorter than 287 milli micron are absorbed by the gases

in the atmosphere. O_3 absorbs ultraviolet radiation from the atmosphere forming ***ozone umbrella.***

3. Suspended particles like dust, clouds and smoke present in the air and clay, silt, plankton and colloids present in the water, screen a certain amount of light.

4. The intensity of light decreases with the increase in the depth of water.

5. Vegetation reduces the intensity of light.

6. At high altitudes, the intensity of light is high.

7. At the equatorial region the intensity of light is higher and it decreases near the latitudes.

Light on Water

About 10% of light falling on water is reflected back to the atmosphere. The remaining 90% of light pass downward. The light rays with longer wavelength are absorbed near the surface and the rays with shorter wavelength penetrate deeper. Infrared rays penetrate upto 4 metres, red and orange rays penetrate upto 20 metres, yellow rays penetrate upto 50 metres and green and blue rays penetrate upto 100 to 200 metres.

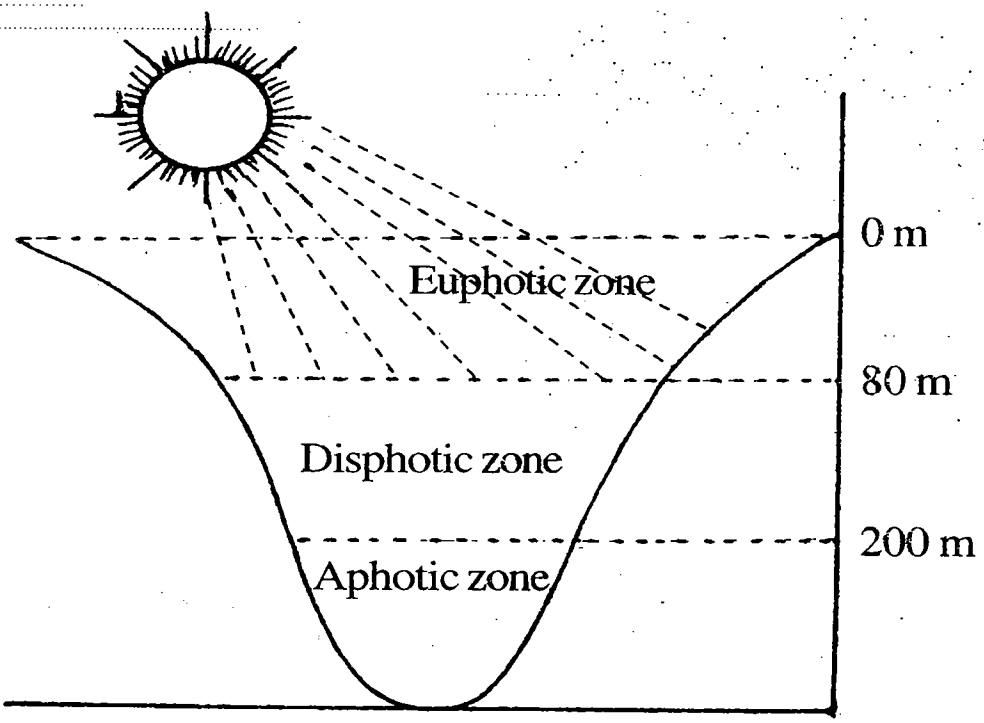


Fig.7.2: Light penetration in the sea.

On the basis of the penetration of light, the water column of ocean is divided into three zones, namely an upper ***euphotic zone,*** a middle ***disphotic zone*** and a lower ***aphotic zone***. The euphotic zone extends down to a depth of 80 metres. It is the lighted zone. The disphotic zone extends from 80 to 200 metres and here the light is highly modified. Aphotic zone is without light and it extends beyond 200 metres.

Biological Effects of Light

1. The Effect of Light on Metabolism

1. The intensity of light influences metabolic rate in animals. Increased intensity of light results in increased enzyme activity.

2. In cave dwelling animals, the metabolic rate is low because of the absence of light.

3. At high intensity the rate of respiration increases.

4. At high intensity protein synthesis is reduced and the production of carbohydrate is increased.

5. The rate of photosynthesis increases with the increasing intensity of light upto the point of light saturation, after this point the rate remains the same.

2. The Effect of Light on Mutation

Ultraviolet light induces gene mutations. Ultraviolet light disrupts the ***thymine*** bases of DNA molecules. When DNA is exposed to UV light two molecules of thymine get connected to give rise to ***thymine dimer***. This will affect the DNA helix and DNA replication. This leads to mutation.

$$\text{Thymine} + \text{Thymine} \xrightarrow{\text{UVL}} \textbf{Thymine dimer}$$

3. Photoreactivation

The UV light damages the DNA molecule by producing thymine dimers. But when the damaged DNA molecule is exposed to visible light, the damage is reversed. This phenomenon is called ***photoreactivation.*** During photoreactivation the thymine dimers are split and the molecule is repaired. Photoreactivation is caused by an enzyme called ***DNA polymerase I.***

4. The Effect of Light on Pigmentation

Light induces ***photochemical reactions*** resulting in the formation of colour pigments called ***melanophores***. The absence of light results in the absence of colour.

1. Cave animals are colourless, because of the absence of light. But when they are exposed to light they develop colour. Eg. *Proteus* (amphibian).

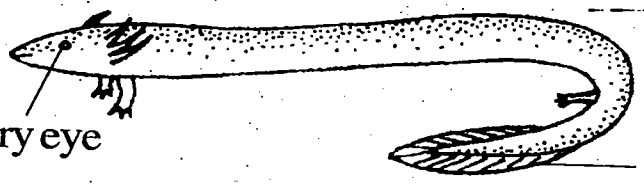


Fig.7.3: Proteus, a cave amphibian, It remains colourless when it is in the cave. It develops dark colour when it is brought to light.

2. Deep sea fishes do not possess colour because of the absence of light.

3. Human beings inhabiting tropical countries like India are darkly pigmented because of the high intensity of light.

4. When aquatic plants or animals are placed in shaded places, they lose their colour.

5. Protective Colouration

Protective colouration is a phenomenon when animals develop different colour patterns to conceal themselves from predators. The colour of the body matches with the colour of any object in the environment. Such formations of colour are influenced by the nature of the light received from the

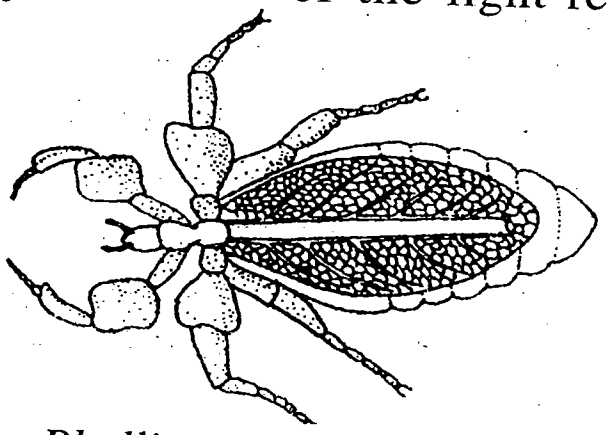


Fig.7.4 : Phyllium, the leaf insect develops the colour pattern of a leaf.

background and in some cases they are activated by direct radiation.

Examples : 1. *Phyllium,* the leaf-insect is green in colour.

2. The moth sitting on trees merges with the colour pattern of the bark.

6. Colour Changes

Some animals have the ability to change their colour according to the intensity of light. Light entering the eye affects the melanophores. More light causes the expansion of the pigment resulting in dark colour. Less light causes the contraction of the pigments resulting in light colour.

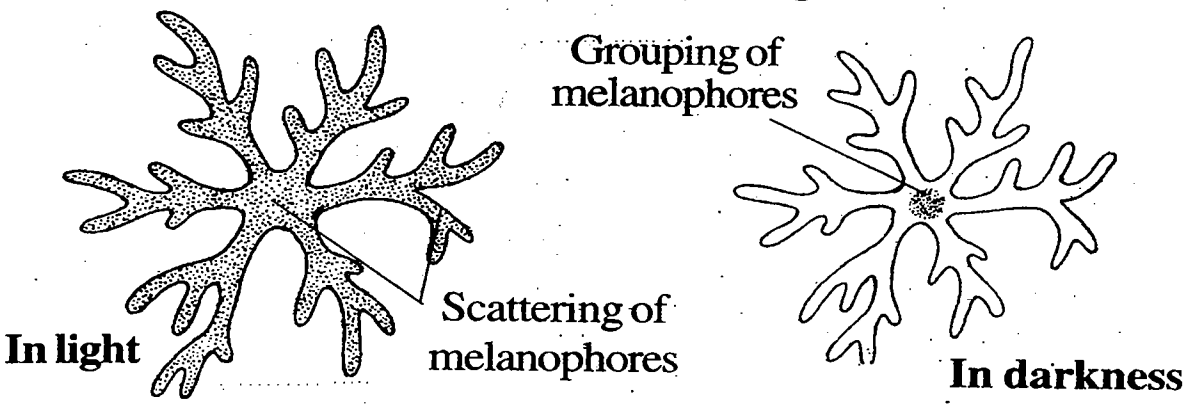


Fig.7.5 : Effect of light on pigment distribution.

Examples: 1. *Chamaeleon* changes its colour according to the colour of the background.

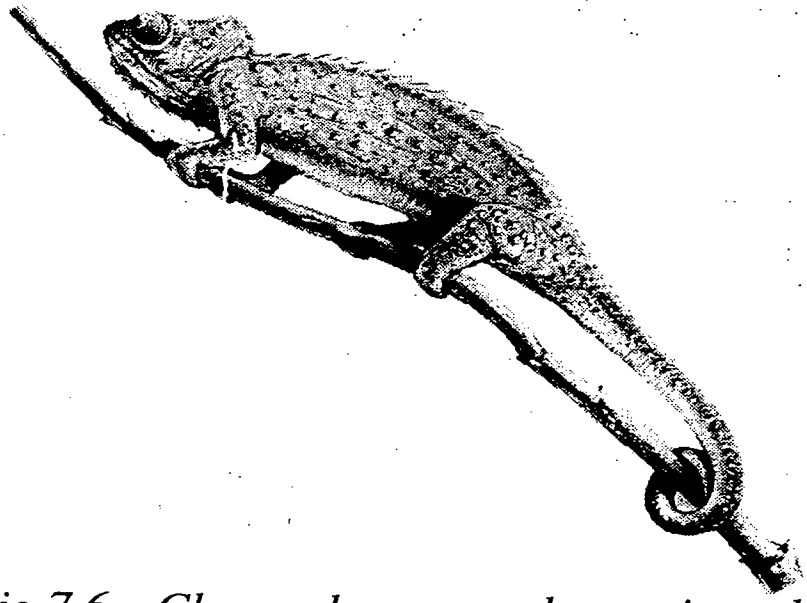


Fig.7.6 : Chamaeleon can change its colour according to the colour of the background.

2. Frogs also change their colour according to their surrounding.

7. Vision

Vision is an important physiological activity that helps to locate the objects in the environment. It requires light. Animals develop different kinds of structures to perceive light. These includes :

1. ***Eye-spots*** in protozoa.
2. ***Ocellus*** in millipedes, centipedes and scorpions.
3. ***Compound eyes*** in crustaceans and insects.
4. ***Pit-eyes*** in gastropods.
5. Vesicular eyes in polychaetes, molluscs and in some vertebrates.
6. Telescopic eyes in certain vertebrates.

Eyes are useful only when the animal is living in a lighted environment. When there is no light in the environment, the eyes are reduced. For example, in the amphibian *Proteus anguinus* living in dark caves eye is completely absent.

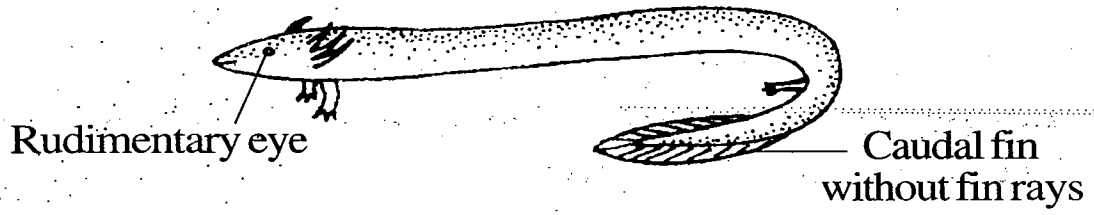


Fig.7.7: Proteus, a cave amphibian. The eyes become rudimentary when it remains in the dark caves. It develops eyes, when it is brought to light.

In the marine habitat, there is very dim light in depths. So the size of the eye increases with increasing depth. Some fishes are provided with ***telescopic eyes***. In nocturnal animals also eyes are large and powerful enough to perceive dim light in the night. Eg. *Owl, loris,* etc.

8. Reproduction

In a great variety of animals, reproduction is influenced by light.

Examples : 1. In *Nereis,* swarming occurs during full moon days.

2. The gonads of birds become more active with increasing light in summer. In winter, the gonadial activity decreases because of short days.

3. In some animals like goats, sheep, deer, etc. gonads are active when the days are short.

According to the influence of light on reproduction, animals are classified into three groups, namely

1. Long day animals

2. Short day animals and

3. Indifferent day length animals.

1. Long Day Animals : These animals are sexually active when the days have more duration. Eg. *Birds, some animals.*

2. Short Day Animals : These animals become sexually active when the days are short. Eg: *Sheep, deer, goats,* etc.

3. Indifferent Day Length Animals : In these animals, sexual activity is not influenced by light. Eg. *Cow, man, guinea pigs,* etc.

9. Parthenogenesis

When sea urchin egg is exposed to ultraviolet light, it begins its development without fertilization.

10. Development

1. The development of the larvae of *Salmon* (fish) will be normal only when there is sufficient light. When light is absent or deficient considerable mortality occurs.

2. The larva of *Mytilus* develops better in ***darkness*** than in light.

11. Photomorphogenesis

Photomorphogenesis is a process by which light dictates the morphology of the plant. It is a well known fact that the plant's fate is decided by light which influences the expression of genes that control the development of a plant. There is a sequence of genes which responds to light and controls the development of plants. These genes are named as ***light responsive elements*** or LREs. Photomorphogenesis occurs in three stages. First of all, the light energy, red light, is absorbed by a blue green pigment

called ***phytochrome***. In the second stage, the light signals are received by the genes (LREs). In the third stage, the genes express themselves by the formation of RNA and proteins. The proteins induce the development of plants.

12. Locomotion and Movement

Light has tremendous influence on the locomotion and movement of animals. The influence of light on the movement of animals can be broadly classified into four categories. They are

1. *Photokinesis*
2. *Phototaxis*
3. *Phototropism* and
4. *Telotaxis.*

1. Photokinesis : Photokinesis is a phenomenon where the speed or velocity of locomotion is influenced by light.

Examples : 1. The larvae of mussel crab *Pinnotheres* move faster when exposed to increased light.

2. *Locusts* (insects) stop their flight when the Sun is hidden by the clouds.

3. The movements of the flies are greatly influenced by the wavelengths of light ***(Bertholf).***

2. Phototaxis : Phototaxis is a phenomenon where the direction of movement is influenced by light. The animals may move towards or away from light. When the movement is towards the source of light, it is called ***positive phototaxis***. Eg. *Euglena* and *Ranatra* (insect). When the movement is away from the source of light, it is called ***negative phototaxis.*** Eg. *Planarians, earthworms, copepods*, etc.

3. Phototropism : It is a phenomenon where only a part of an organism moves in response to light. Phototropism is ***positive*** when the part of the organism moves towards the source of light and it is ***negative*** when the part of the organism moves away from the source of light. Eg. Movement of flagellum of *Euglena,* movement of polyps of coelenterates and the movement of tubicolous worms.

4. Telotaxis : The movement of males towards the flash of females is called ***telotaxis***.

13. Photoperiodism

The response of animals to the length of the day is called ***photoperiodism***. The length of the day between sunrise and sunset is called ***photoperiod***.

Examples : 1. The migration of birds is affected by light. When the day is long, birds migrate towards the North and when the day is short they migrate towards South.

2. Seasonal migration of birds is under the influence of the day length.

3. Sexual activity in birds is increased with increasing photoperiod.

4. Laying eggs in the case of hen is stimulated by increasing length in day.

5. ***Diapause*** is a period of suspended activity in winter in some insects. The larvae of pink cotton ballworm goes into diapause during winter when the days are short. Emergence from diapause begins after spring when the days are slightly longer. But when these larvae are exposed to artificial light in the laboratory for 13 to 15 hours, they can be prevented from going into diapause.

6. In mammals and birds, the development of fur and feather is related to photoperiod.

7. Trouts spawn in autumn. But in the laboratory they can be induced to spawn in summer when the length of the day is increased artificially.

8. The reproductive activities of plants are influenced by photoperiod. Accordingly plants are classified into three categories, namely ***long day plants*** producing flowers and seeds during summer when the days are long, ***short day plants*** producing flowers and seeds when the days are short and ***neutral plants*** which are not affected by photoperiod.

14. Diurnal Migration

In the sea, certain planktonic organisms migrate to the depth from the surface in the early morning and to the surface from the depth in the evening. This cyclical daily movement is called

6. Temperature

Temperature is a ***physico-chemical, ecological, abiotic factor***. It is defined as the ***intensity aspect of heat***. It is a form of energy and is called ***thermal energy***. It penetrates into each and every region of the biosphere. It affects all forms of life. It influences the various stages of life activities, such as growth, metabolism, reproduction, movement, distribution, behaviour, death, etc.

Measurement

Temperature is usually measured in Fahrenheit (F^o) or centrigrade (C^o).

Sources

The biosphere obtains its thermal energy mainly from the Sun in the form of ***solar radiation.*** The heat is emitted by the ***visible light (vibgyor)*** and the ***infrared rays*** of the electromagnetic spectrum. So the temperature at the earth's surface depends on the brightness of the Sun.

Ranges of Temperature

Temperature is a variable factor. It varies from place to place and time to time. In the day it is high and in the night it is low. It is high at the sea-level and low at high altitudes. It is high at the equator and low in the polar regions. It is high in the terrestrial habitat and low in the aquatic habitat. It is high in the open land and low in the shady places.

Temperature Range in the Terrestrial Habitat

The maximum temperature recorded on land is 85°C as in deserts and the lowest temperature is -70°C as in ***Siberia.*** The temperature on terrestrial habitat is characterized by much fluctuations. The fluctuations are determined by various factors like day and night, altitude, latitude, seasons, etc.

Diurnal Variation

The temperature is high during day time and low during night time. This difference in temperature is called ***diurnal variation***. Usually day temperature varies from 30°C to 42°C and night temperature varies from 12°C to 18°C. Hence the diurnal variation is 18°C to 24°C. But it is high in deserts. This is because in deserts the temperature is very high in the day and very low in the night.

Altitude

The temperature on land is high at the sea-level, but it is low at high altitudes. An increase in altitude of 150 metres results in a decrease in 1°C temperature.

Latitude

On land, maximum temperature is found in the equatorial line. It gradually decreases towards the poles.

Seasons

On land, the temperature varies from season to season. The temperature reaches its maximum during ***summer*** while it is minimum during ***winter***.

Temperature Range in the Aquatic Habitat

The maximum temperature record in water is 36°C and the minimum temperature is -2.5°C. The temperature fluctuation in aquatic habitat is lesser than that of terrestrial habitat. But the fluctuation depends on the depth and topography. Increase in depth decreases temperature fluctuations. In marine habitat, the temperature ranges from 2.5°C in Arctic and Antarctic waters to 36°C in tropical seas. Ocean provides constant temperature when compared to terrestrial habitat.

Thermal Stratification

In deep freshwater habitats, as in lakes and ponds, there is a gradual decrease in temperature from the surface to the bottom. As a result, different layers of water with different temperatures is noticed. The arrangement of different layers in the aquatic medium according to the nature of temperature differences is called ***thermal stratification***. They are of two types:

1. Summer stratification and

2. Winter stratification

1. Summer Stratification

In summer, there are three distinct layers, namely an upper layer called ***epilimnion,*** a middle layer called ***thermocline*** or ***metalimnion*** and a lower layer called ***hypolimnion***.

A. Epilimnion : 1. It is the upper layer of water.

2. It is the warmer layer.

3. The temperature of this layer fluctuates with the temperature of the atmosphere. It will be about 27°C to 21°C.

4. In this layer, water is continuously stirred by wind.

B. Hypolimnion : 1. It is the bottom layer.

2. Water is cool.

3. Temperature is between 5°C to 7°C.

4. Water is stagnant.

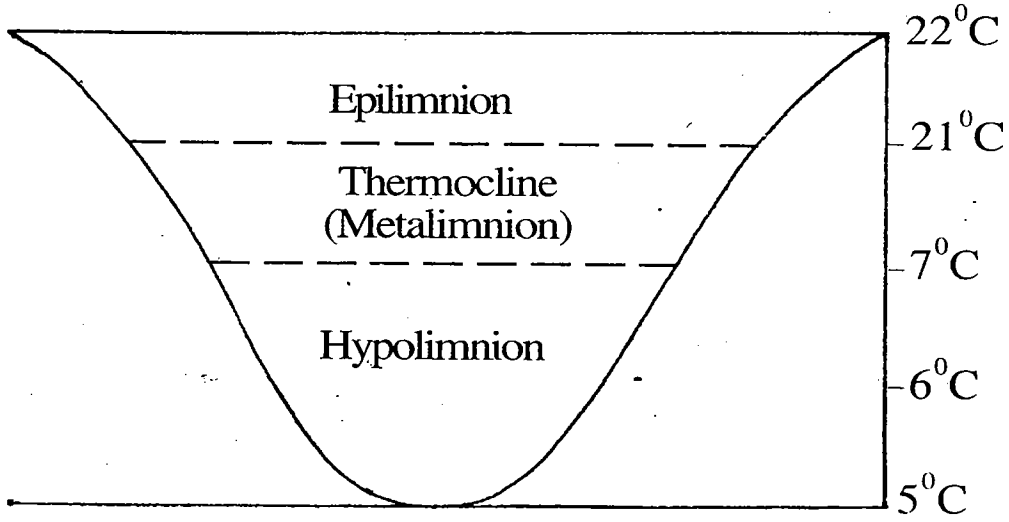


Fig.6.1 : Summer stratification of a lake.

C. Thermocline or Metalimnion : 1. It is the middle layer.

2. The temperature is inbetween that of the upper layer and that of the lower layer.

3. It is characterized by a gradation of temperature from top to bottom.

4. Temperature is 21°C above and 7°C below with gradual decrease from top to bottom.

5. It is also called ***transition zone***.

2. Winter Stratification

In winter, two layers are seen. They are an ***upper layer*** and a ***lower layer***. The temperature of the upper layer is reduced to 0°C and the water there becomes ice. In the lower layer, the temperature of the water column remains 4°C throughout.

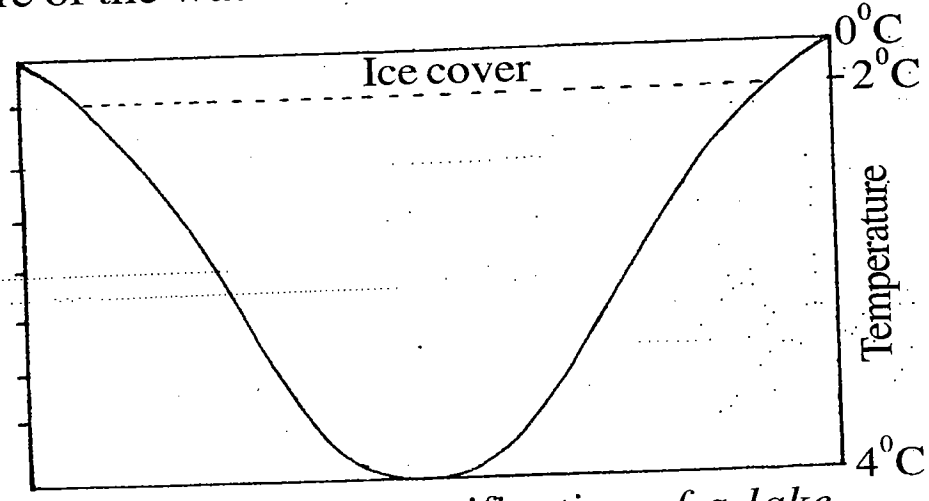


Fig.6.2 : Winter stratification of a lake.

Biological Effects of Temperature

1. Tolerance to Temperature :-

Each and every organisms has a particular range of temperature at which the organism survives well. This temperature is called ***optimum temperature***. At the optimum temperature the physiological activities are high and hence the organisms survive better.

The lowest temperature at which an organism can live indefinitely in an active state is called ***minimum effective temperature***. The lowest temperature at which survival is possible is called the ***minimum survival temperature***. The highest tem-

perature at which an organism can live indefinitely in an active state is called the ***maximum effective temperature***. The highest temperature at which survival is possible is called the ***maximum survival temperature***.

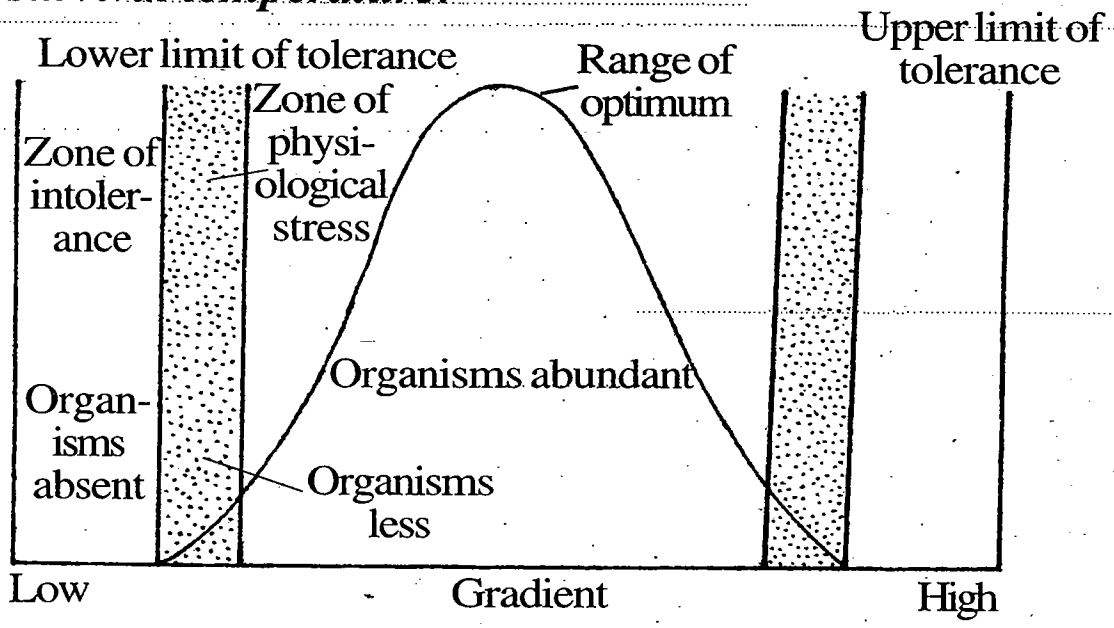


Fig.6.3: Graph showing the tolerance to temperature.

2. Eurythermal and Stenothermal Organisms

The organisms which can tolerate wide ranges of temperature fluctuations are called ***eurythermal organisms.*** They have adaptations to adjust themselves to the fluctuations in temperature. Eg. *Man, lizards, amphibians,* etc.

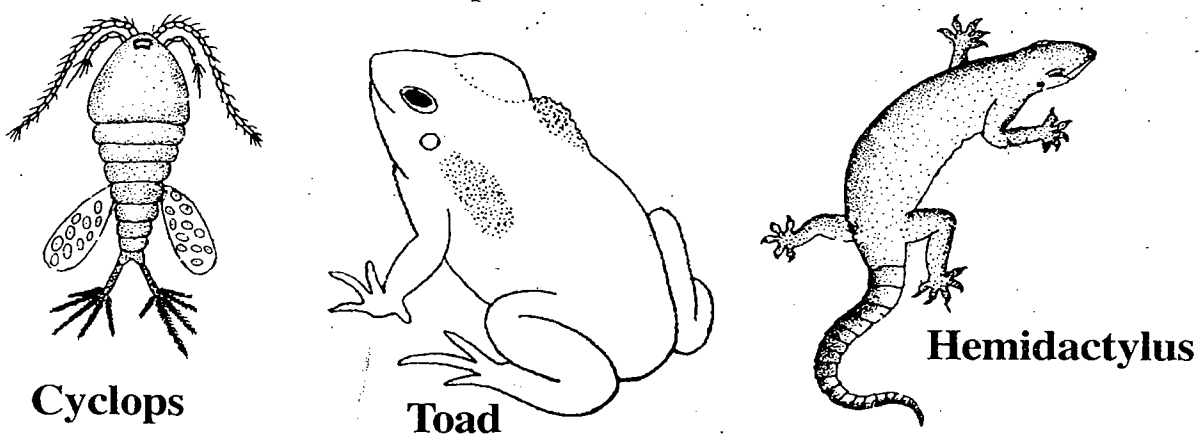


Fig.6.4: Some eurythermal organisms.

Organisms which cannot tolerate wide ranges of temperature fluctuations are called ***stenothermal organisms.*** They have no adaptations to adjust themselves to the fluctuations in temperature. Eg. *Corals, snails,* etc.

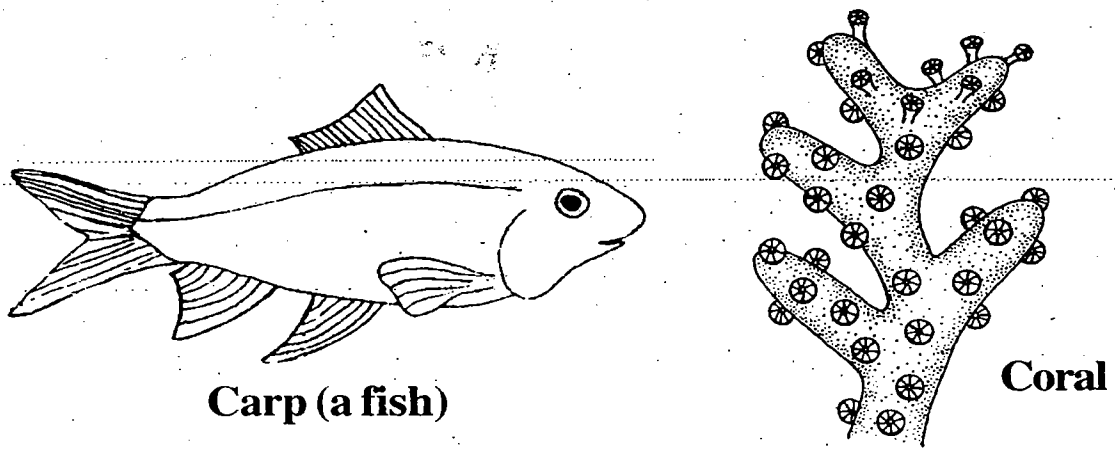


Fig.6.5: Some stenothermal organisms.

3. Poikilothermic Animals or Thermo Confirmers

In many animals, the body temperature changes according to the fluctuations of environmental temperature. These animals are called ***poikilothermic animals***. *When the environment is cold, their blood also becomes cold.* Hence they are also called ***cold blooded animals.*** They cannot regulate their body temperature by metabolism; but they gain temperature from the environment. Hence they are also called ***ectothermic animals.*** Eg. *All animals except birds* and *mammals.*

4. Homeothermic Animals or Thermo Regulators

In some animals, the body temperature remains constant and it is independent of environmental temperature. These animals are called ***homeothermic animals.*** When the environment is cold the blood of these animals will be at a higher temperature. Hence these animals are also called ***warm blooded animals.*** They can regulate their body temperature by generating heat through metabolic activities. Hence they are also called ***endothermic animals.*** Eg. *Birds* and *mammals.*

5. Heterothermic Animals

Heterotherms behave like ***ectotherms*** and ***endotherms.*** Like endotherms, they generate heat. But they cannot regulate their body temperature within a narrow range like endotherms. Eg. *Many flying insects, tunas, mackerals, mako sharks, pythons, Echidna, camel,* etc.

6. Effect of Temperature on Metabolism and Reaction Rate

Metabolic (biochemical) activities are catalyzed by enzymes. Enzymes, in turn, are influenced by temperature. Hence fluctuations of temperature bring about marked changes in metabolic activities. The rates of chemical reactions are increased as the temperature is raised. However, this increase happens only upto a certain limit, the optimum temperature. Above the optimum temperature, the enzyme is denatured and inactivated. As the enzyme is inactivated, the reaction slows down and ultimately stops. The effect of temperature on enzymes and hence on metabolism can be represented in the form of a curve.

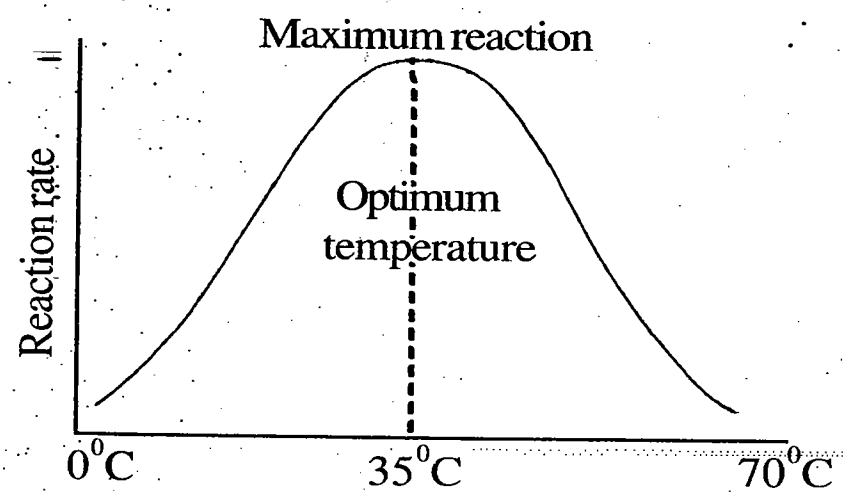


Fig.6.6: Effect of temperature on metabolism and reaction rate.

Vant Hoff's Rule : Chemical reactions are speeded up by rising temperature. This has been expressed by ***Vant Hoff's rule***. It states that the *rate of chemical reactions are doubled for every 10° increase in temperature.* This increase is presented as Q_{10}. Q_{10} refers to ***the effect of temperature on reaction rate.*** For most biological processes Q_{10} ranges from 1.5 to 3. This means that for every rise of 10°C, there is an increase of 1.5 to 3 times. Q_{10} varies with animals.

$$Q_{10} = \frac{K_2}{K_1} \quad x \quad \frac{10}{(t_2 - t_1)}$$

Here, t_1 = initial temperature

t_2 = final temperature
K_1 = rate of activity at t_1°C
K_2 = rate of activity at t_2°C

Examples : 1. The activity of the liver enzyme arginase goes on increasing with the increase in temperature from 17°C to 48°C. Further increase in temperature results in the retardation of enzyme activity.

2. In freshwater mussel, the heart beat, oxygen consumption and ciliary activity are increased with increase in temperature.

3. At high temperature, the food intake in cattle is reduced.

4. The chirping of crickets is higher in warm weather and lower in cool weather.

5. The intake of food in the case of fish is increased twofold or threefold when temperature is raised from 10°C to 20°C.

7. The Effect of Temperature on Growth

Temperature affects the growth of animals. Eg. 1. The oyster *Ostraea virginica* grows to 1.4 mm when it is reared at 10°C. But when it is reared at 20°C, it grows to 10.3 mm.

2. The sea-urchin *Echinus esculentus* grows to its maximum size when the water is warm.

3. The trout fish does not grow in water in a temperature of less than 10°C and the maximum growth takes place between 13 °C and 19°C.

8. The Effect of Temperature on Development

Temperature influences the development of organisms. Eg. 1. The egg of mackeral (fish) does not develop below 8°C and above 25°C. But it starts to develop at 10°C. The time required for hatching, decreases with the rise in temperature from 10°C to 21°C. For example, the egg hatches in 207 hours at 10°C, in 150 hours at 12°C and in 50 hours at 21°C.

2. Trout eggs develop four times faster when the temperature is raised from 5°C to 15°C.

3. For the complete development of one generation, the chironomid fly *Metriocnemus hirticollis* requires 26 days at 20°C, 94 days at 10°C and 153 days at 6.5°C.

9. Effect of Temperature on Neotenous Forms

Low temperature prevents metamorphosis and makes the animal ***neotenous***. For example, *Ambystoma tigrinum* remains in the larval stage indefinitely in the cold waters of rocky mountains while in the warm plains metamorphosis takes place.

Fig.6.7: Ambystoma tigrinum. It remains in the larval stage (Axolotl) indefinitely in the cold waters. It becomes adult in the warm plains.

10. Effect of Temperature on Reproduction

The reproduction of animals is influenced by temperature. Eg. 1. In blow-fly *Calliphora sericate,* egg-laying starts at 22°C and it increases with the rise of temperature upto 32.5°C. Further increase in temperature decreases the number of eggs laid.

2. The insect acridid *Chrotogonus trachypterus* becomes sexually mature and lays more number of eggs at 30°C.

3. The grasshoppers *Melanoplus sanguinipes* and *Camnula pellicida* produce 20 to 30 times more eggs at 32°C than at 22°C.

11. The Effect of Temperature on Sex-ratio

When temperature is allowed to increase, the sex-ratio is affected. Eg. 1. In the copepod *Macrocyclops albidu* the males increase in number when the temperature rises.

2. In the case of plague-flea *Zenopsylla cheopis;* parasitic on rats, the males outnumber the females on days of warm temperature ranging between 21°C and 25°C.

12. The Effect of Temperature on Colouration

The insects, birds and mammals living in warm humid regions (tropical regions) are dark in colour due to the development of more pigments. But the animals living in cool and dry climates (polar regions) are pale in colour. This phenomenon is called ***Gloger's rule***.

13. The Effect of Temperature on Morphology

The morphological characters of organisms are altered by the temperature.

1. Bergman's Rule : Temperature influences the size of animals and the relative proportions of the parts of the body. This phenomenon is called ***Bergman's rule***. Birds and mammals living in colder regions attain maximum size.

Examples : 1. Penguins which are found in Antarctica attain a body length of 100 cm to 200 cm whereas the penguins of the equatorial Galapagos islands are about 49 cm long.

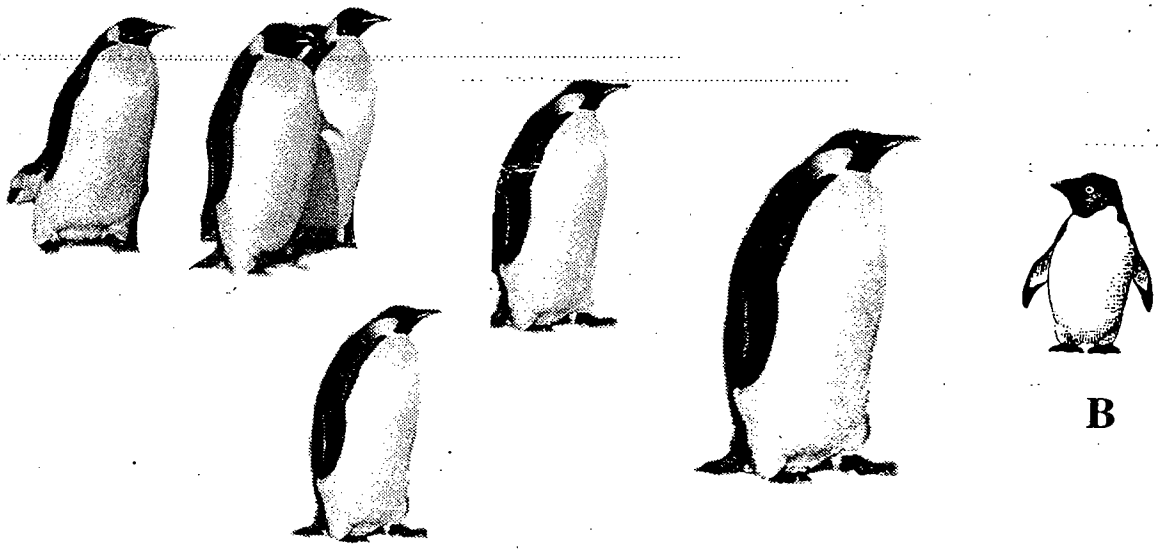


Fig.6.8: Bergman's rule : A. Emperor penguin of Antarctica is larger. B. Penguin of Galapagos island is smaller.

2. The biggest bears are found in cold northern regions. Eg. *Polar bears* and *Kodiak bears*. The smallest bears are found in high temperature regions. Eg. *Black bears*.

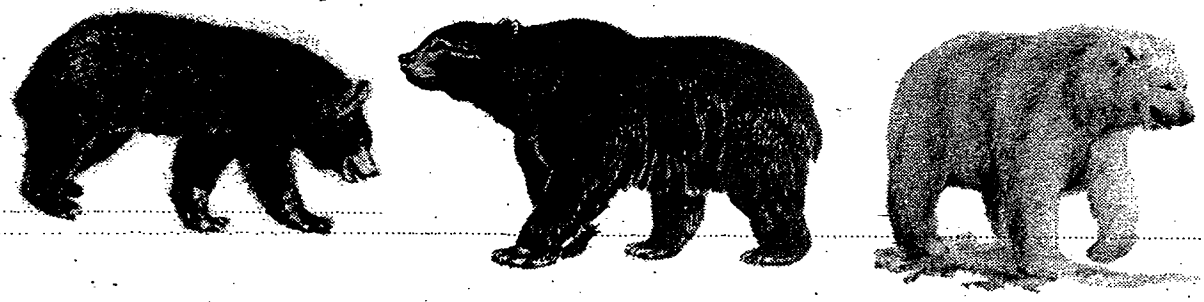
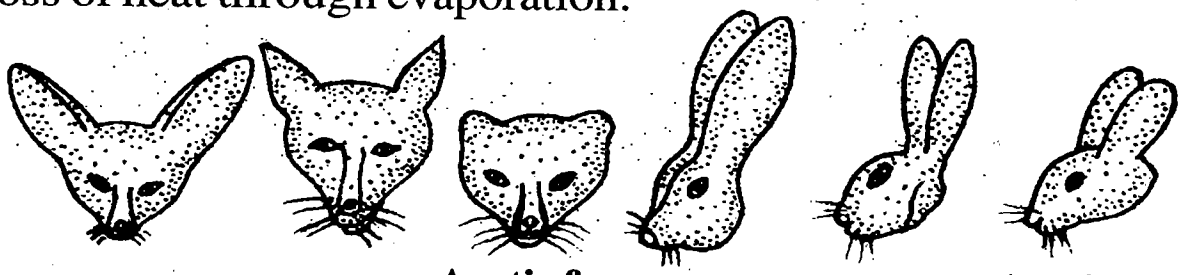


Fig.6.9: Bergman's rule : Bears of northern colder region are larger (Kodiak bear). Bears of high temperature regions are smaller (Black bear).

2. Allen's Rule : According to ***Allen*** the extremities of mammals, like the tail, snout, ears and legs are relatively shorter in colder parts than in warmer parts. This phenomenon is called ***Allen's rule.***

Examples : 1. In the Arctic rabbit ears are shorter. In Californian rabbit ears are longer.

2. In the arctic fox *Alopex logopus,* ears are short, in red fox *Vulpes vulpes* ears are medium sized and in desert form *Megalotis zerda,* ears are longer. Short ears prevent the loss of heat in colder regions. The large ears of desert fox help in the loss of heat through evaporation.



Arctic fox **Arctic hare**

Fig.6.10: Allen's rule : Arctic fox and Arctic hare have small ears. Fennec fox and jack rabbit live in warm regions and they have large ears. Red fox and hare live in places that are neither very hot nor very chill. They have medium sized ears. Big ears help to lose heat. Small ears help to keep heat in.

3. Mice reared at 31 to 33.50°C have longer tails than those of the same strain reared at 15.5 to 20°C.

4. Eskimos have shorter arms and shorter legs in proportion to the size of their trunks.

3. Jordan's Rule : The fishes living in cold waters are provided with a greater number of vertebrae than in the case of the species that live in warm waters. This phenomenon is called ***Jordan's rule***.

4. Rensch's Rule : The birds surviving in colder regions are provided with narrow wings while those in warmer climate are provided with broader wings. This phenomenon is called ***Rensch's rule***.

14. Effect of Temperature on Distribution

Temperature is a limiting factor in the distribution of animals. *The distribution of warm blooded animals is not much affected by temperature.* For example, tiger has its normal home in the hot districts of India but it is also found in colder climates. Similarly the Indian elephants can live in cool high mountains and in warm forests.

The influence of temperature on distribution is much more marked in cold blooded animals. For example, the amphibians and reptiles are abundant in tropical and temperate regions and their number rapidly diminishes towards the poles.

Animals with a narrow range of temperature tolerance (***stenothermal***) are restricted to specific parts.

Examples : 1. Coral reefs require a minimum temperature of 21°C for their existence; hence they are not found in the colder regions.

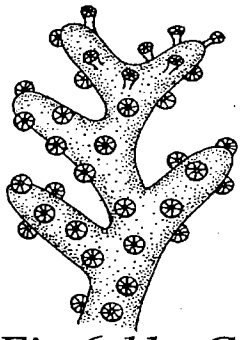


Fig.6.11: Coral.

2. *Pecten groenlandicus* is not found in places where the temperature is above 0°C.

15. Effect of Temperature on Cyclomorphosis

Cyclomorphosis may be defined as *the cyclic changes in the morphological structures of organisms in relation to seq-*

4. Medium - Water

Medium** is the material which immediately surrounds the organism.* The organism lives inside the medium and it makes biological exchange with the medium. Medium is an ***abiotic environmental factor. The medium is inevitable for the survival of the organisms. Every organism has a medium.

The medium is divided into two main types. They are the following:

1. *Water medium* and
2. *Air medium*

Water

Water is aptly described as the ***mother of life.*** It is the ***liquid -gold.*** It is the ***universal solvent.*** It is the largest medium of life. It occupies 71% of the earth's surface. Actually, the name ***'earth'*** for our planet is a misnomer because the land part of our planet is only 29%, the remaining 71% being water. Hence the correct name for our planet should be ***'water'*** and not earth.

1. Structure of Water

Water is a simple ***inorganic compound*** formed by the combination of hydrogen and oxygen.

$$2H_2 + O_2 \rightarrow 2H_2O$$

2. Forms of Water

Water exists in three forms, namely ***liquid, solid*** and ***vapour.***

1. Liquid State

It exists in two forms, namely ***seawater*** and ***freshwater.*** Freshwater may be present on the surface of the earth as ***surface water*** in ponds, lakes, rivers, etc. or under the earth's surface as ***ground water.***

2. Solid State

The solid state of water is called ***ice.*** When the temperature of water drops below 0^0C water freezes to become ice.

3. Vapour State

It is the ***gaseous state.*** When the temperature of water increases, it evaporates to become vapour. It exists in two forms, namely invisible ***humidity*** and visible ***cloud.*** The moisture present in the atmospheric air is called ***humidity.*** When air moves up from land surface to the colder levels of atmosphere, the moisture of air cools down to form cloud.

3. Sources of Water

The main sources of water are

1. *Precipitation*
2. *Ground water*
3. *Springs*
4. *Sea*
5. *Ponds*
6. *Lakes*
7. *Rivers,* etc.

All forms of water falling on the earth from atmosphere is called ***precipitation.*** Rainfall is the most common form of precipitation. Snow, sleet and hail are the other forms of precipitation.

4. Types of Water

Based on the types of salts present in the water, the water is classified into ***1. Hard water*** and ***2. Soft water.***

1. Hard Water

Hard water does not give foam with soap. It contains soluble chlorides, sulphates and bicarbonates of Ca and Mg ions.

2. Xerocoles

These are terrestrial animals which can tolerate dry conditions and survive long time without water. They have adaptations for desert life. Eg. *Moloch horridus, Phrynosoma,* etc.

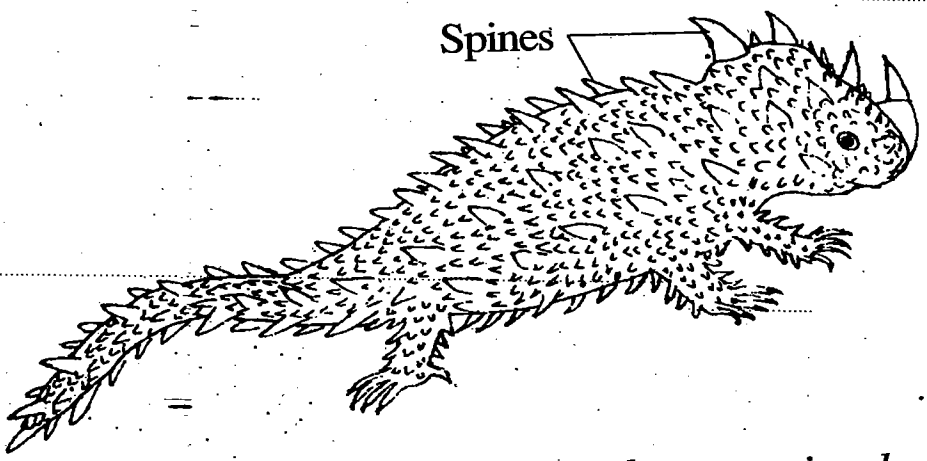


Fig.4.2: Moloch horridus, a desert animal.

3. Mesocoles

These animals require moderate amount of water. They exhibit amphibious mode of life. Examples: *Land planarians, Earthworms* and *Amphibians.*

7. Properties of Water

1. Solvency

Water is the only solvent which dissolves maximum number of organic and inorganic substances. Hence it is called ***universal solvent.*** This property makes majority of the pollutants dissolve and makes water highly polluted.

2. Specific Heat

Specific heat is defined as *the number of calories necessary to raise 1 gram(ml) of water to 1^{0}C. The specific heat of water is 1.0. This is very high when compared to other liquids.* As a result water is capable of storing tremendous quantities of heat energy with a relatively small rise in temperature.

3. Latent Heat

Latent heat is *the quantity of heat required to change a substance from the solid state to the liquid state or from the liquid state to the gaseous state.* Water has high latent heat. As a result large quantities of heat energy must be removed before

water can change from the liquid state to solid state. Similarly, it must absorb considerable amount of heat before ice can be converted into the liquid state. This property has great biological significance.

4. Thermal Conductivity

Among liquids, water has the highest heat conductivity. This helps to maintain uniform temperature. The thermal conductivity of water is 0.0125.

5. Viscosity

The viscosity of water is high. It reduces friction. Viscosity allows only little energy for the movement of organisms. It also protects the aquatic organisms from mechanical disturbances.

6. Surface Tension

The surface tension of water is high. This helps certain insects to work and run on the surface of water.

7. Buoyancy

The buoyancy of an object is equal to the weight of the water it displaces. It varies with the density of water. Water is a buoyant medium. So organisms can easily float on water.

8. Density

The density of water is directly proportional to the concentration of dissolved salts and inversely proportional to temperature. Water is denser at 4^0C. It freezes to ice at 0^0C. Ice is lighter. Hence it always floats on the surface of the water. This helps animals to live at the bottom.

9. Salinity

The salinity of seawater is high and that of freshwater is low. Salinity remains constant in seawater but it varies in freshwater and estuaries.

Salinity acts as a ***limiting factor*** in the distribution of animals. Due to salinity, animals are adapted either ***euryhaline*** or ***stenohaline*** or both ***euryhaline*** and ***stenohaline*** mode of life.

10. Pressure

Pressure is *the weight of the water column above an organism plus the weight of the atmosphere.* Pressure increases with increasing depth. In freshwater, pressure is much lesser than that in the marine habitat.

11. Transparency

Transparency is the property of water by which it allows light to pass through so that objects in the depth can be seen. In freshwater, transparency is decreased by suspended materials like clay, silt, waterplants, plankton blooms, etc. These objects cause ***turbidity.*** Turbidity prevents the penetration of light into the water. This reduces photosynthesis and productivity of an aquatic environment.

Transparency is measured by a simple ecological instrument called ***Secchi disc***. This instrument was designed by ***Secchi*** in 1865. It is circular in shape. It has four quarters. Two alternate quarters are black in colour and the other two are white in colour.

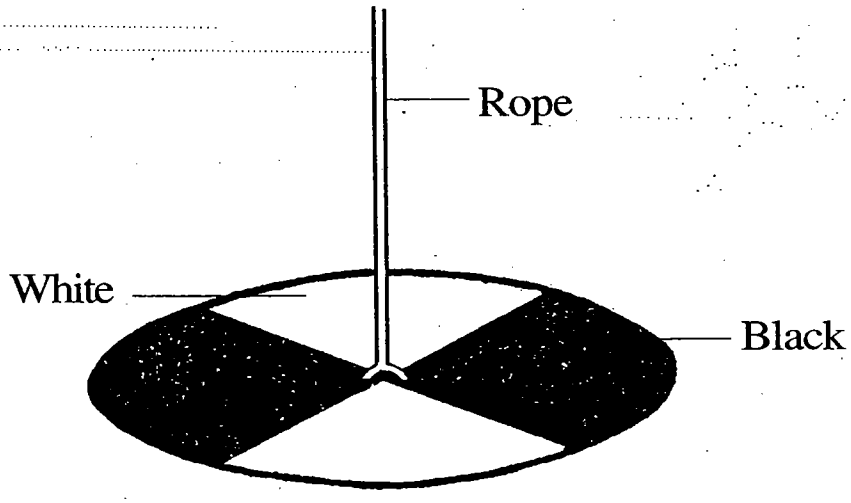


Fig.4.3: Secchi disc, used to measure transparency.

The disc has a hook in the centre, from which a rope arises. To measure transparency, the disc is slowly dropped in water and the depth, at which the disc disappears is noted. Similarly the disc is slowly lifted. The depth at which the disc appears is noted. The average of the two readings is the transparency of water.

12. Hydrogen ion concentration (pH)

The negative logarithm of hydrogen ion (H^+) *concentration in water* is called ***pH.*** It depends on the amount of two components present in water. They are hydrogen ions (H^+) and hydroxyl ions (OH^-).

When water contains equal number of H^+ and OH^-, it is said to be ***neutral with a pH value of 7.0.*** When an amount of water contains more H^+, it is said to be ***acidic*** with pH value ***less than 7.0***. When a particular amount of water contains more OH^-, it is said to be ***alkaline*** with a pH ***higher than 7.0.*** One molecule of water is split up into 10,000,000 H^+ and OH^- ions. This splitting up of water molecule is called ***photolysis*** of water.

$$H_2O \leftrightarrow H^+ + OH^-$$

pH is a limiting factor in the distribution of animals. pH variation is high in freshwater than in seawater. The pH of seawater ranges between 7.4 and 8.4. But in freshwater it varies from 1.2 to 7.2.

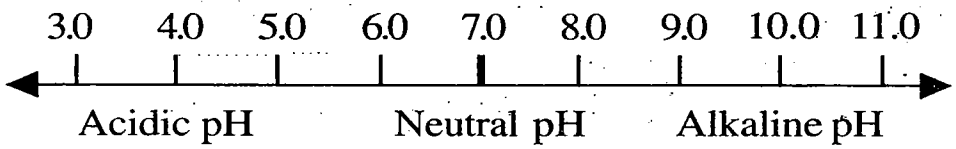


Fig.4.4 : pH Scale.

13. Temperature

Temperature variation is much lesser in water than in terrestrial habitat. The changes occur very slowly. Compared to marine habitat, the temperature variation in freshwater habitat is higher.

Thermal Stratification

In deep freshwater habitats, such as lakes and ponds, there is a gradual decrease in temperature from the surface to the bottom. As a result, different layers of water with different temperatures are noticed. This is called ***thermal stratification.***

Summer Stratification

In summer, there are three distinct layers, namely an upper layer called ***epilimnion,*** a bottom layer called ***hypolimnion*** and a middle layer called ***thermocline*** or ***metalimnion.***

1. Epilimnion

1. It is the upper layer of water.
2. It is the warmer layer.
3. The temperature of this layer fluctuates with the temperature of the atmosphere. It will be about 27°C to 21°C.

2. Hypolimnion

1. It is the bottom layer of water.
2. At this level water is cool.
3. The temperature is between 5°C and 7°C.
4. It is a stagnant water column or standing water column.

3. Thermocline (metalimnion)

1. It is the middle layer.
2. The temperature is in between the temperature of the upper layer and that of the lower layer.
3. It is characterized by a gradation of temperature from top to bottom.
4. Temperature is 21°C above and 7°C below with gradual decrease from top to bottom.
5. It is also called ***transition zone.***

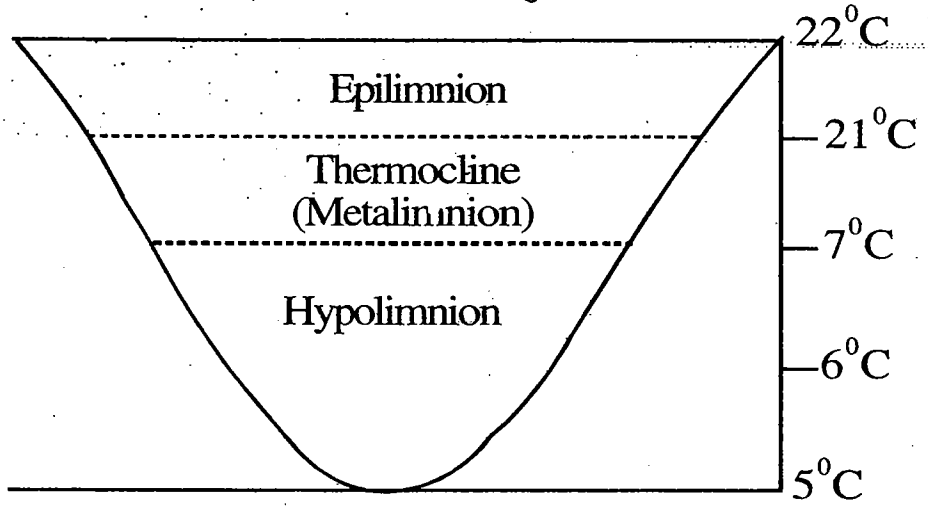


Fig.4.5 : Summer stratification of a lake.

Winter Stratification

In winter two layers are seen. They are an upper layer and a lower layer. The temperature of upper layer is reduced to 0°C and the water becomes ice. In the lower layer the temperature of the water column remains 4°C throughout.

2. Structure

Each community has a definite structure. It is formed of three groups of organisms, namely ***producers, consumers*** and ***decomposers.***

1. Producers

The green plants constitute the producers. They are ***autotrophs***. They can synthesize starch by ***photosynthesis*** utilizing chlorophyll, CO_2, water, minerals and solar energy. The producers form the main source of energy for the other components of the community. Eg. *Plants, Phytoplankton,* etc.

2. Consumers

Consumers are the ***heterotrophs***. They cannot produce food, utilizing abiotic factors. But they depend on the producers and other organisms of the community for their food. Consumers are of two types, namely ***herbivores*** and ***carnivores***.

1. Herbivores : *Herbivores are animals which eat the producers.* They are also called ***primary consumers*** because they form the first order of consumers. Eg. *Deer, rabbits* in forest community; *Zooplankton* and *plant eating fishes* of pond community.

2. Carnivores : Carnivores are animals which eat other animals for their food. These are also called ***secondary consumers*** because they form the second order of consumers. Eg. *Fox, Lion* and *Tiger* of forest community, *Fishes, Frogs* and *Snakes* of pond community.

Carnivores are further sub-divided into ***primary carnivores, secondary carnivores*** and ***tertiary carnivores***.

The primary carnivores are depend on herbivores for their food. The secondary carnivores depend on primary carnivores and the tertiary carnivores depend on secondary carnivores.

3. Decomposers

Decomposers include micro-organisms like ***bacteria*** and ***fungi.*** They decompose the dead bodies of plants and animals of the community and convert them into micro and macro nutrients. These nutrients are again utilized by plants for photosynthesis.

Pond is a suitable example for ecosystem. ***Forest*** is another ecosystem. The ***sea*** forms the ***marine ecosystem***. Other examples of ecosystem are ***river, estuary, ocean, grassland, town,*** etc.

The word ***ecosystem*** was coined by ***A.G. Tansley*** in 1935. This term is derived from two words, namely ***eco*** and ***system***. ***Eco*** refers to environment and ***system*** refers to a complex co-ordinated unit.

Structure

The structure of any ecosystem is formed of two components, namely 1. *Abiotic factors* and 2. *Biotic factors.*

1. Abiotic Factors

The abiotic factors of an ecosystem include the non-living substances of the environment. Eg. *Water, soil, air, light, temperature, minerals, climate, pressure*, etc.

2. Biotic Factors

The biotic factors include the living organisms of the environment. Eg. *Plants, animals, bacteria, viruses*, etc.

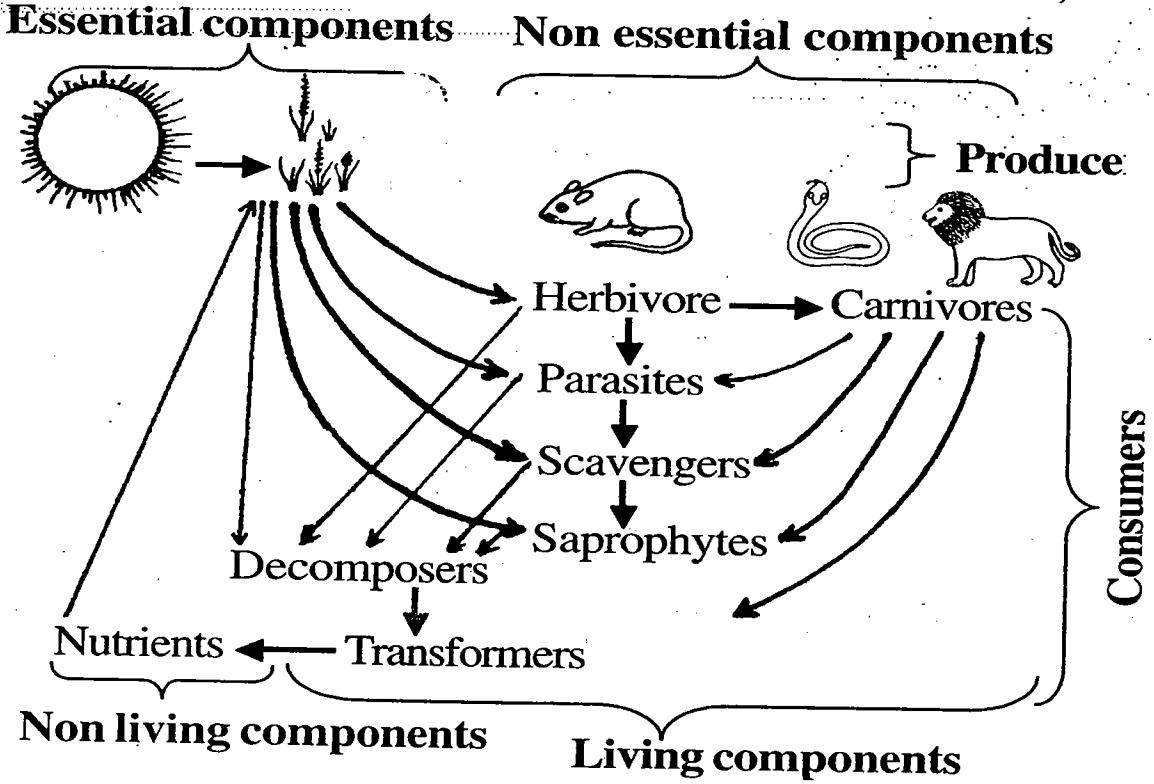


Fig.11.2: Components of an ecosystem.

The biotic factors of the ecosystem depend on the abiotic factors for their survival.

The biotic factors of an ecosystem are classified into three main groups, namely 1. ***Producers*** 2. ***Consumers*** and 3. ***Reducers*** or ***decomposers***.

1. Producers

The organisms which carry out photosynthesis constitute the ***producers*** of an ecosystem. Eg. *Plants, algae* and *bacteria.*

The producers depend on the abiotic factors of the ecosystem for producing energy. They contain ***chlorophyll.*** Chlorophyll is used for the synthesis of food with the utilization of abiotic factors like light, CO_2, water and minerals. This process is called ***photosynthesis.***

The producers use inorganic substances of the abiotic factors and convert them into organic food materials.

A portion of the food synthesized, is used by the producers for their growth and survival and the remaining food is stored for future use.

2. Consumers

Consumers are organisms which eat or devour other organisms. All animals are consumers. The consumers are further divided into three or more types. They are ***primary consumers, secondary consumers*** and ***tertiary consumers***.

Primary Consumers : They eat the producers like plants, algae and bacteria. The primary consumers are also called ***herbivores***. ***Elton*** referred the herbivores as ***key industry animals***. Rabbit, deer, cow, goat, etc. are primary consumers in a terrestrial ecosystem.

Secondary Consumers : They kill and eat the herbivores. They are also called ***carnivores***. As these carnivores directly depend on herbivores, they are called ***primary carnivores***. Fox, wolf, etc. are the ***secondary consumers*** in a terrestrial ecosystem.

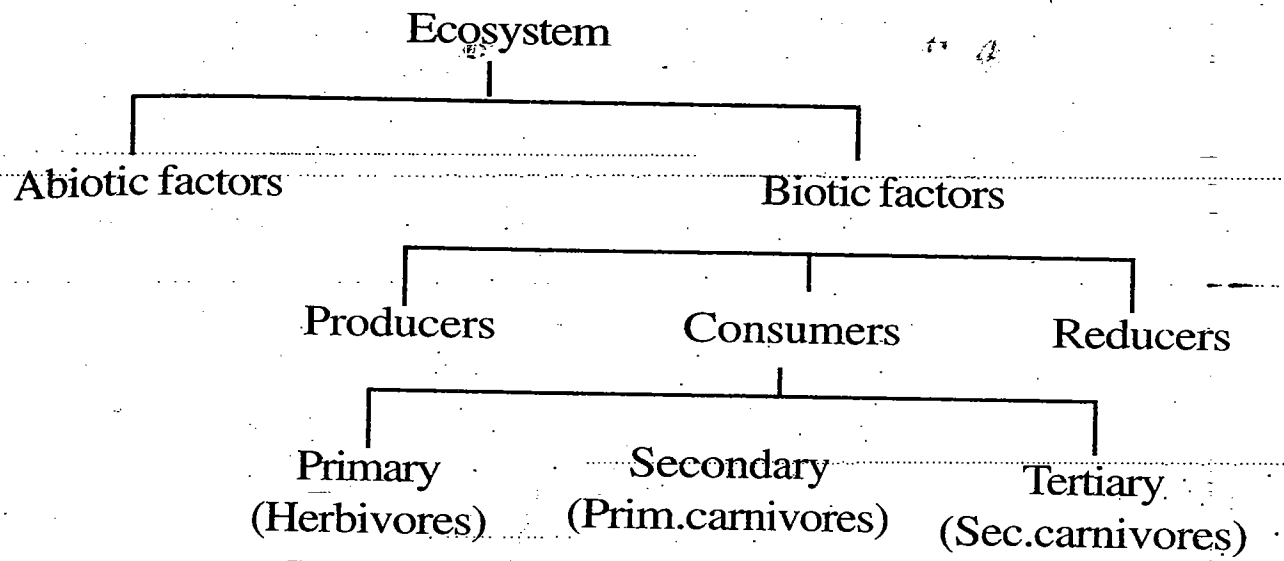


Fig.11.3: Structure of an ecosystem.

Tertiary Consumers : They kill and eat the secondary consumers. They are also called ***secondary carnivores***. Eg. *Lion, tiger,* etc.

3. Reducers or Decomposers

The reducers or decomposers are organisms that break up the dead bodies of plants and their waste products. They include ***fungi*** and certain ***bacteria.*** They secrete enzymes. The enzymes digest the dead organisms and the debris into smaller bits or molecules. These molecules are absorbed by the reducers. After taking energy, the reducers release molecules to the environment as chemicals to be used again by the producers.

Types of Ecosystem

The ecosystem may be large, as large as the World or small, as small as a cow dung ecosystem. The ***biosphere*** (the total life content of the World) is the major ecosystem. It comprises all other ecosystems.

1. Mega Ecosystems

The biosphere is formed of four ***mega ecosystems.*** They are as follows :

1. Marine Ecosystem : It includes saline water ecosystems like oceans, seas, estuaries, brackishwaters, etc.

1. Pond Ecosystem

A pond is a suitable example for aquatic ecosystem. It is a ***lentic*** (***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 of the pond ecosystem are water, CO_2, O_2, inorganic compounds, organic compounds, light, temperature, pressure, pH, etc.

2. Biotic Factors

The biotic factors of the pond ecosystem are plants and animals. They are ***producers, consumers*** and ***reducers*** or ***decomposers.***

1. Producers

The producers synthesize the food from abiotic substances. They carry out ***photosynthesis.***

The producers of pond include ***phytoplankton*** like diatoms, blue green algae *(Oscillatoria)*, green algae, green flagellates *(Volvox, Euglena, Chlamydomonas)*, rooted plants, submerged plants and floating plants.

2. Consumers

Consumers eat other organisms. The organisms which depend on producers are called ***primary consumers*** or ***herbivores***. Eg. *Zooplankton (Cyclops, Daphnia, Chironomus larvae*, etc.), *Dysticus* (insect), *Lymnaea* (snail), etc.

The primary consumers are eaten by the ***secondary consumers*** or ***carnivores.*** These carnivores are called ***primary carnivores*** because they are the first carnivores in the food chain. Eg. *Small fishes, frogs*, etc.

The secondary consumers are eaten by the ***tertiary consumers*** or ***secondary carnivores.*** Eg. *Large fishes, snakes,* etc.

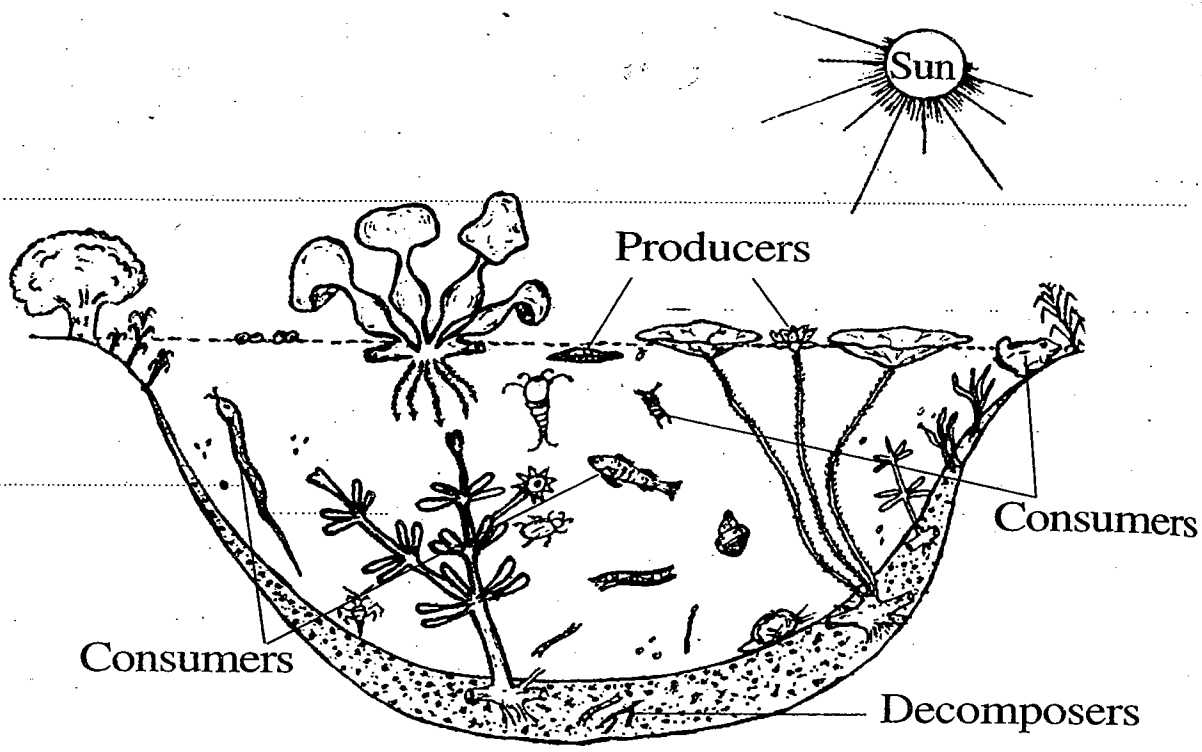


Fig.11.20: Pond ecosystem.

3. Reducers or Decomposers

The reducers or decomposers are organisms that break up the dead bodies of other organisms and their waste products. They include microbes like bacteria and fungi. They secrete enzymes.

The enzymes digest the dead organisms and the debris into smaller bits or molecules. These molecules are absorbed by the reducers.

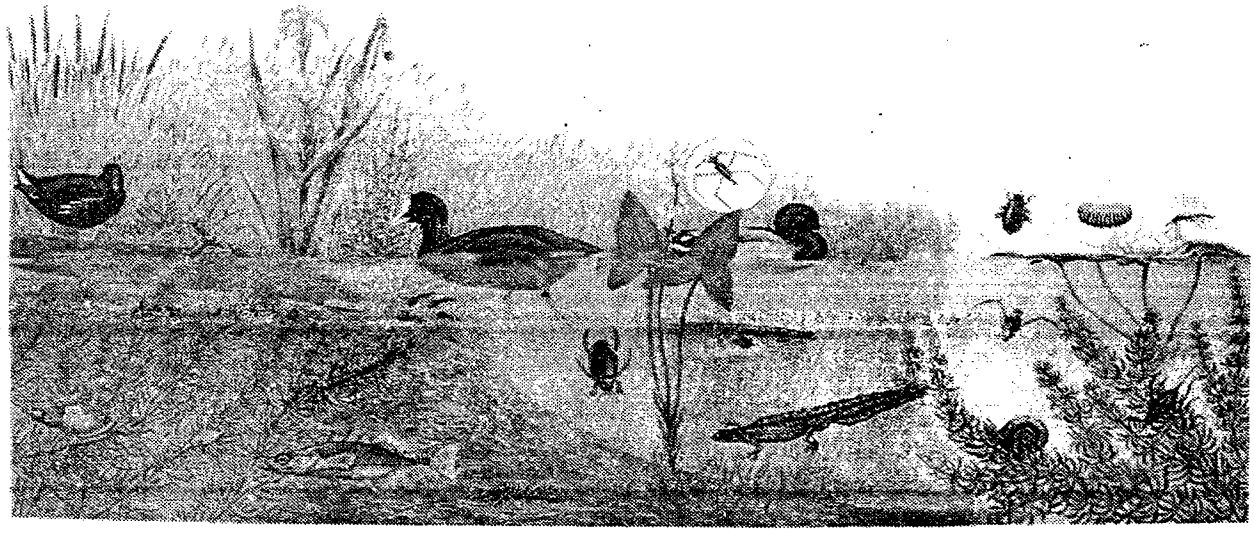


Fig.11.21: Pond ecosystem.

After taking energy, the reducers release the molecules to the environment as chemicals to be used again by the producers.

2. River Ecosystem

- River is a ***lotic*** water habitat.
- It is a ***running water*** ecosystem.
- It is an ***aquatic ecosystem.***
- Ecosystem is an ***ecological unit.***
- It has ***water current.*** Water is in motion.
- The major rivers of India are Ganga, Yamuna, Bramaputra, Thungapatra, Cauvery, Vaigai, etc.
- The river ecosystem is made up of two components, namely ***abiotic components*** and ***biotic components.***
- The abiotic components are the ***non-living factors*** such as river, soil, water, light, temperature, etc.
- The biotic components are the ***living factors.***
- The living components are the plants and animals.
- The plants include phytoplankton, algae, water plants, etc.
- The animals include nymphs of insects, beetles, snails, freshwater mussels, fishes, frogs, water snakes, turtles, birds, etc.
- The biotic components are of three types, namely ***producers, consumers*** and ***decomposers.***
- The producers are the plants. They synthesize food by ***photosynthesis.***
- The consumers are the animals.
- The consumers are of two types, namely ***herbivores*** and ***carnivores.***
- The herbivores eat the plants. Eg. *Fishes.*
- The carnivores eat the animals. Eg. *Snakes.*
- The decomposers break the dead bodies of plants and animals.

◆ The process of eating being eaten is called ***food chain.***

◆ In the ecosystem, ***energy flows*** from the producers to consumers.

◆ The minerals circulate between the living and non-living components of the ecosystem. It is called ***biogeochemical cycle.***

3. Stream Ecosystem

Stream is a river flowing down the hills.

It is a ***running (lotic)*** water.

It is a ***freshwater ecosystem.***

It is an ***aquatic ecosystem.***

The fauna and flora are similar to that of a river (The student may read a river ecosystem for further details).

4. Lake Ecosystem

❖ A lake is a large freshwater body of water which has no connection with the sea. Eg. *Yercaud lake, Lake Superior, Lake Baikal,* etc.

❖ It is a ***standing water body (lentic).***

❖ It is of great depth.

❖ It is an ***aquatic ecosystem.***

❖ It is a ***freshwater ecosystem.***

❖ The lake is of three types, namely ***oligotrophic lake, eutrophic lake*** and ***dystrophic lake.***

❖ ***Oligotrophic lakes*** are young lakes; they are deep; they are poor in fauna and flora.

❖ ***Eutrophic lakes*** are shallow. They are shallow but rich in fauna and flora.

❖ ***Dystrophic lakes*** are shallow or deep. They are poor in fauna and flora.

❖ A lake ecosystem is similar to a pond ecosystem (The student may read and write pond ecosystem).

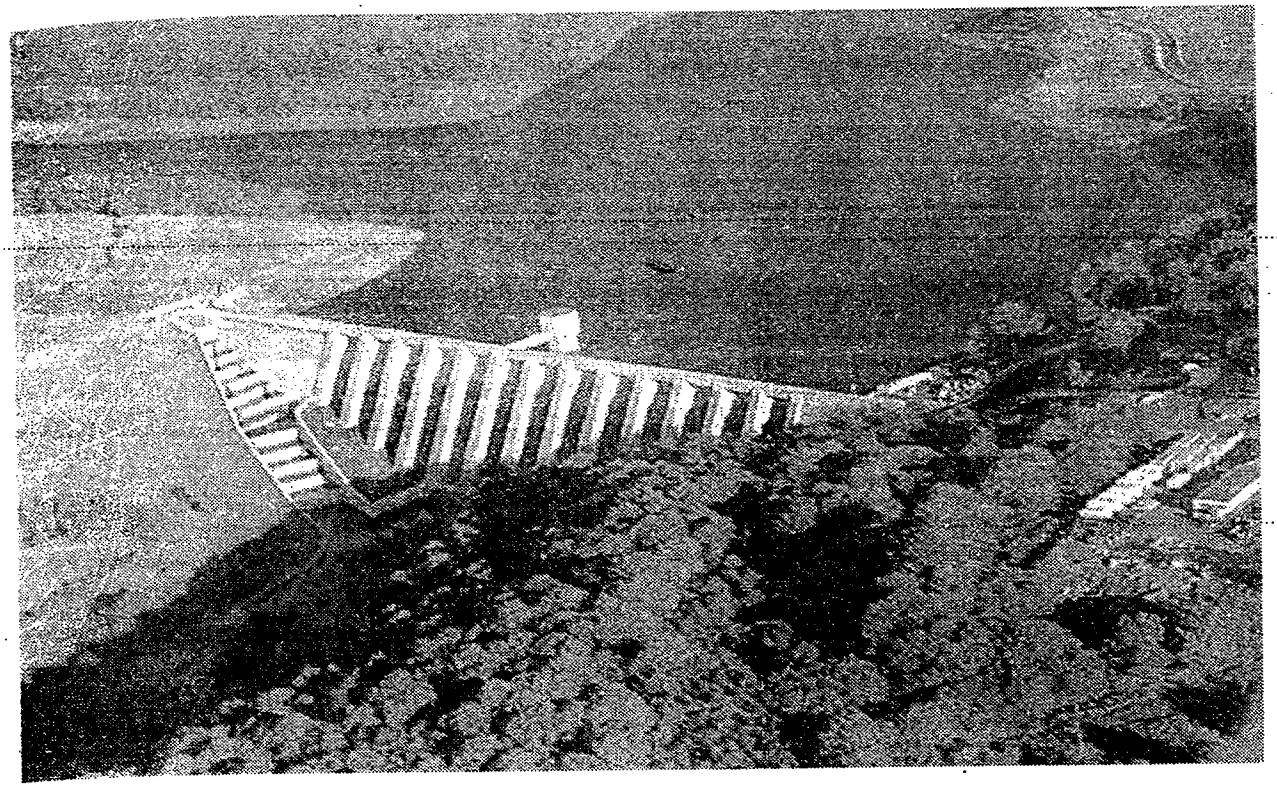


Fig.11.22: Lake ecosystem.

5. Marine Ecosystem (Sea Ecosystem)

☯ Marine ecosystem comprises the sea and oceans. Eg. *Atlantic ocean, Pacific ocean, Indian ocean.*

☯ Ecosystem is an ***ecological unit.***

☯ It is a ***megaecosystem*** (large).

☯ It is the largest ecosystem in the World because it occupies 70% of the Earth's surface.

☯ It consists of ***salt water.***

☯ The salt content of the marine ecosystem is 3.2%. i.e. 3.2 parts of salt for 100 parts of water. It is usually written as ***32‰.*** i.e. 32 parts per thousand. That is, 32 part of salt (weight) per 1000 parts of water.

☯ Marine ecosystem has a wealth of ***aqua food.***

☯ The marine ecosystem consists of ***abiotic factors*** and ***biotic factors.***

☯ The abiotic factors (non-living) include seawater, bottom mud, temperature, light, etc.

9. Desert Ecosystem

❄ An ecosystem is a ***basic functional ecological unit.***

❄ 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.

❄ An ecosystem is *a sum total of living organisms, the environment and the process of interaction between and within all parts of the system (**Mathavan**, 1974).*

❄ In deserts, the rainfall is less than 10 cm.

❄ Temperature is very high.

❄ Air movements and storms are common in deserts.

❄ Deserts occupy one fifth of the Earth's surface.

❄ The ***Thar*** desert covers an area of 15,00,000 sq. km.

❄ The desert is a ***biome.***

❄ It is a ***terrestrial ecosystem.*** It is a self sustaining ecological system.

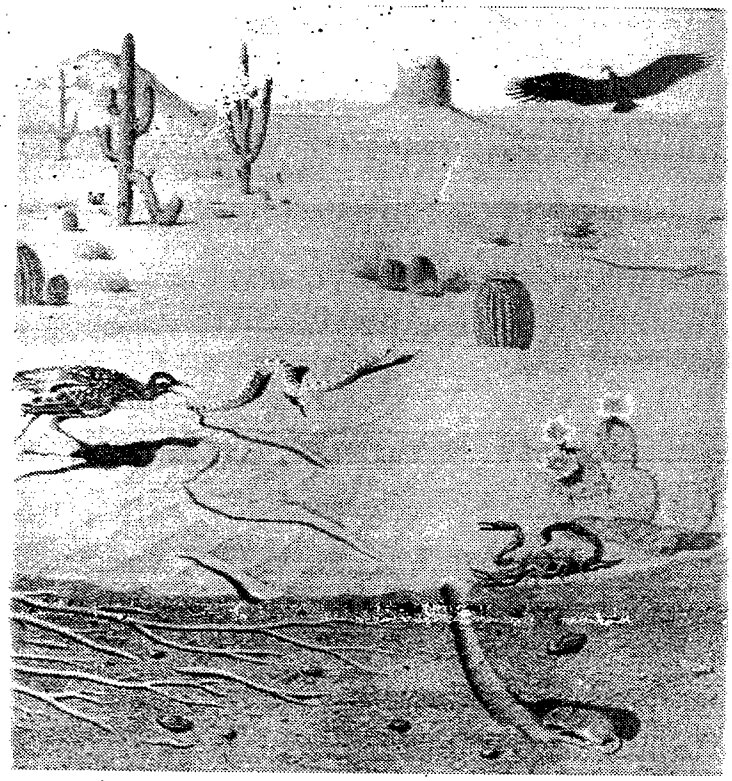


Fig.11.28: Desert ecosystem.

❄ A desert ecosystem is made up of two components, namely ***abiotic*** and ***biotic components.***

❄ The abiotic components include non-living things such as sand, water, air, light, temperature, etc.

❄ The biotic components include living things such as ***plants*** and ***animals.***

❄ The plants of a desert include succulent plants, thorn bushes, shrubs and some trees. Eg. *Yuccas, Agaves, Cacti,* etc.

❄ The animals include ***camel, kangaroo rat, antelope, owls, hawks, Uromastix, Molach, Phrynosoma, Rattle snake, insects, spiders,*** etc.

❄ The biotic components of the desert consists of ***producers, consumers*** and ***decomposers.***

❄ The producers are the desert plants.

❄ The consumers are the animals, ***herbivores*** and ***carnivores.***

❄ The decomposers are the ***bacteria*** and ***fungi.*** They break the dead bodies of plants and animals.

❄ The producers are eaten by the herbivores. The herbivores are eaten by the carnivores. This process of eating being eaten is called ***food chain.***

Producers → **Herbivores** → **Carnivores**

Fig.11.29: Food chain.

❄ The ***energy flows*** in the ecosystem from the producers to consumers.

❄ The minerals circulate between the living and non-living components of the ecosystem. It is called ***biogeochemical cycle.***

The consumers store some amount of energy in their tissues. This energy, stored by the consumers, is called ***secondary production.***

Only about 10 to 20% of the primary production is converted into secondary production. The remaining 80 to 90% is lost by the consumers in the form of faeces.

4. Food Chain

The sequence of the eaters being eaten is called ***food chain.***

The biotic factors of the ecosystem are linked together by food. For example, the producers form the food for the herbivores. The herbivores form the food for the carnivores.

Producers → **Herbivores** → **Carnivores**

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

Owing to repeated eating being eaten, the energy is transferred from one trophic level to another trophic level. This transfer of energy from one trophic level to another is called ***energy flow.***

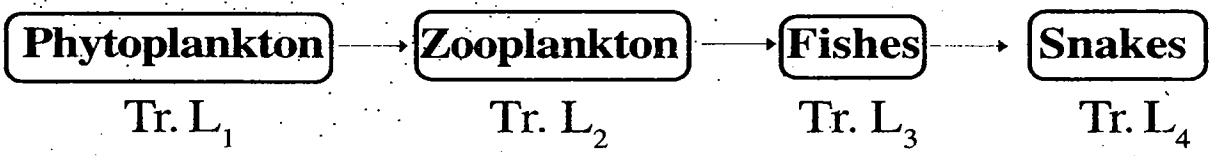


Fig.11.5 : Four trophic levels of a food chain in a pond ecosystem.

Plants → Mouse → Snake → Hawk - ***Grassland***
Plants → Goat → Man → Lion - ***Forest***

Fig.11.6: Energy flows through food chains. The direction of arrows indicate the direction of energy flow.

A typical food chain can be seen in a pond ecosystem. The algae and phytoplankton are eaten by the zooplankton.

The zooplankton are eaten by fishes. The fishes are eaten by snakes.

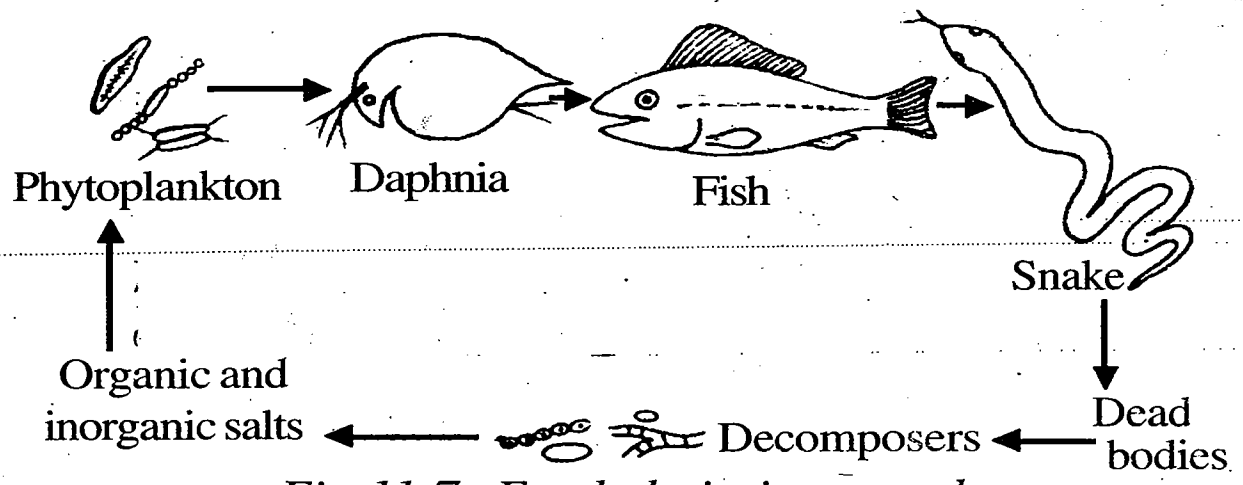


Fig.11.7: Food chain in a pond.

The food chains are of two types, namely 1. *Grazing food chain* and 2. *Detritus food chain.*

1. Grazing Food Chain

This food chain starts from plants, goes through herbivores and ends in carnivores.

Plants → Herbivores → Primary Carnivores → Sec. carnivores

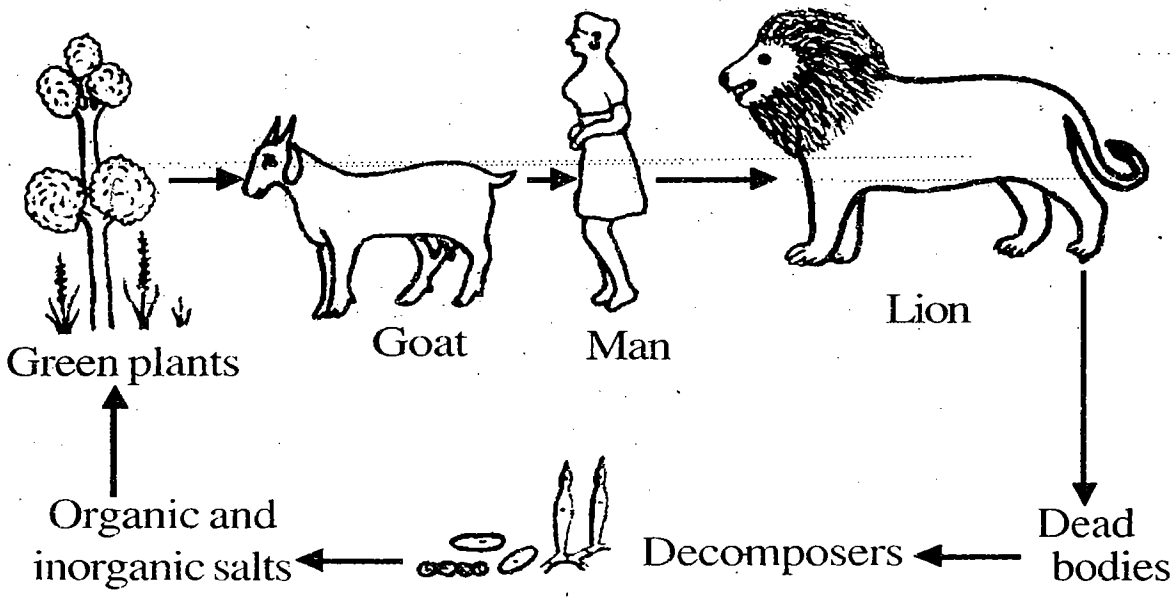


Fig.11.8: Food chain in a forest.

This type of food chain depends on the autotrophs which capture the energy from solar radiation. A few chains are given below :

Grass → Grasshopper → Lizard → Hawk

Grass → Mouse → Snake → Hawk

Phytoplankton → Zooplankton → Fish → Snake.

The grazing food chain is further divided into two types, namely a. ***Predator food chain*** and b. ***Parasitic food chain.***

a. Predator Food Chain

In predator food chain, one animal captures and devours another animal. The animal which is eaten is called ***prey*** and the animal which eats other animals is called ***predator***. The predator food chain is formed of plants, herbivores, primary carnivores, secondary carnivores and so on.

b. Parasitic Food Chain

The plants and animals of the grazing food chain are infected by parasites. The parasites derive their energy from their hosts. Thus the ***parasitic chain*** is formed within the grazing food chain.

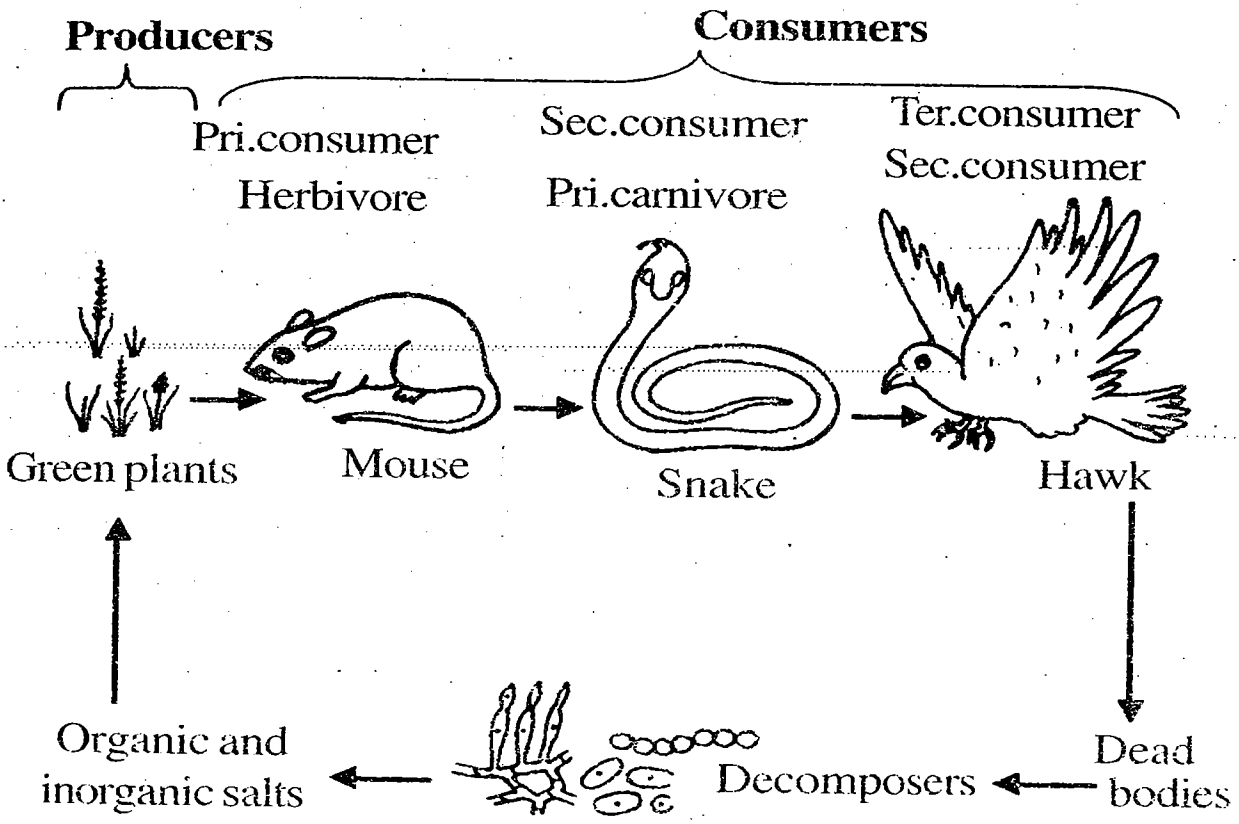


Fig.11.9: Food chain in a grassland.

2. Detritus Food Chain

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

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

Some amount of energy is trapped and the remainder is excreted in the form of simple organic compounds.

These are again used by another set of detritivores until the organic compounds are converted into CO_2 and water.

Dead organic materials → Detritivores → $CO_2 + H_2O$

Linking of Grazing and Detritus Food Chains

The two main food chains cannot operate independently. They are interconnected at various levels.

According to ***Wilson*** and ***Bossert*** (1971) *the stability of the ecosystem is directly proportional to the number of such links.*

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

Again some of the detritus feeders are eaten by the consumers of the grazing food chain. For example, in a pond ecosystem earthworms belonging to the detritus food chain are eaten by fishes belonging to the grazing food chain.

5. Food Web

In an ecosystem, the various food chains are interconnected with each other to form a network called ***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 organisms of the higher trophic level.

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. In addition, hawk

also directly eats 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.11.10: Five linear food chains of a grassland food web.

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

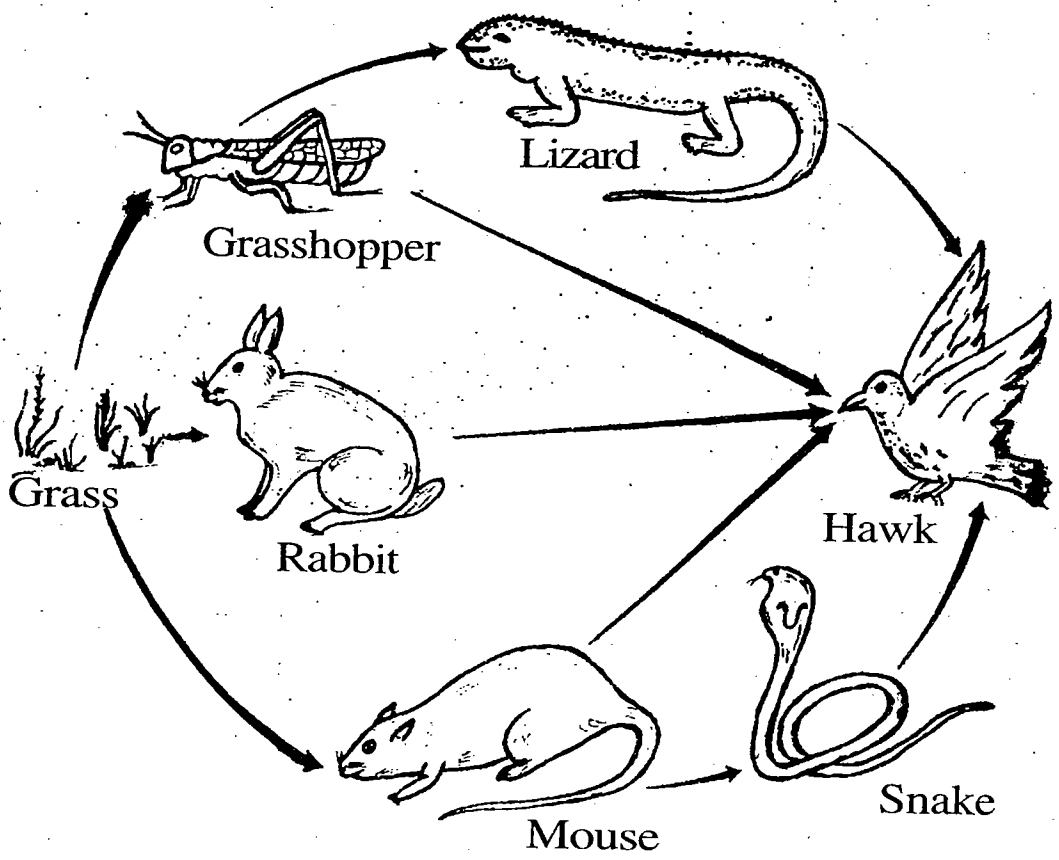


Fig.11.11: Food web in a grassland ecosystem.

Significance of Food Web

Food webs are very important in maintaining the stability of an ecosystem. For example, 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 becomes extinct, the carnivore predating on this type may eat another type of herbivore.

6. Trophic Levels

Each food chain contains many steps like producers, herbivores, primary carnivores and so on. Each step of the food chain is called a ***trophic level.*** The number of trophic levels in a food chain is always restricted to 4 or 5. But very often the chains are very much complicated with many trophic levels.

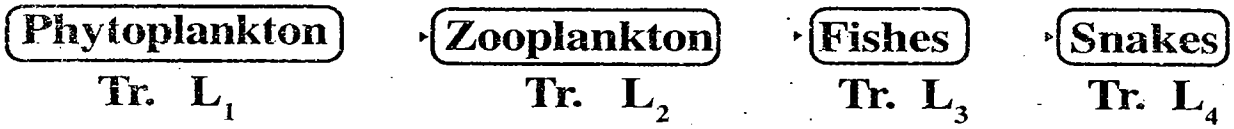


Fig.11.12: Trophic levels of a food chain in a pond ecosystem.

7. Energy Flow

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.*** That is, 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 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.

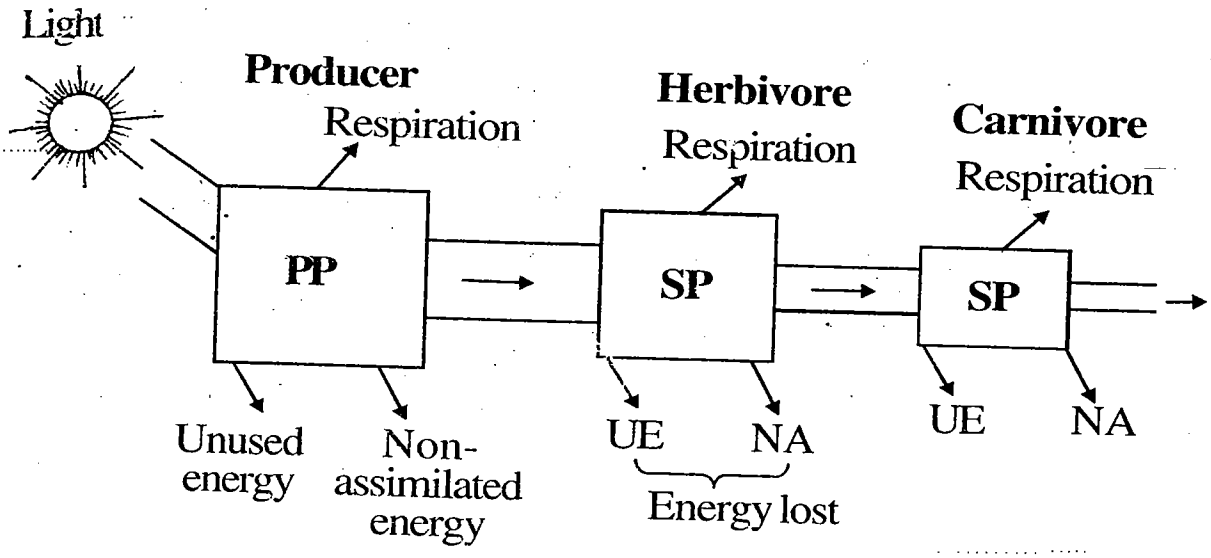


Fig.11.13: Energy flow.

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% is transferred to the body of carnivores. 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.

8. Ecological Pyramids

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 ***ecological pyramid.***

Ecological pyramid is *the graphical representation of the number, biomass and energy of the successive trophic levels of an ecosystem.*

The use of ecological pyramid was first described by ***Charles Elton*** in 1927.

In the ecological pyramid, the producer forms the base and the final consumer occupies the apex. There are three types of ecological pyramids, namely

1. *The pyramid of number*
2. *The pyramid of biomass* and
3. *The pyramid of energy*

1. The Pyramid of Number

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

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

In a Cropland Ecosystem: In croplands, the crops are more in numbers. The grasshoppers feeding on crop plants are lesser in number.

The frogs feeding on grasshopper are still lesser in number. The snakes feeding on frogs are fewer in number.

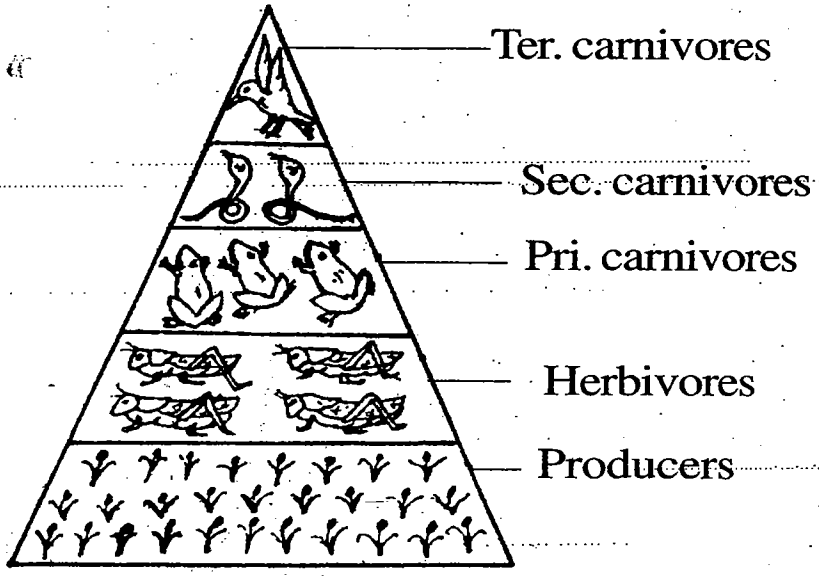


Fig.11.14: Pyramid of numbers in a cropland ecosystem.

Crop → Grasshopper → Frog → Snake → Hawk

In a Grassland Ecosystem : In grasslands, the grasses are there in large numbers. The consumers decrease in the following order:

Grass → Grasshopper → Lizard → Hawk

Grass → Rabbit → Fox → Lion

In a Pond Ecosystem : The number in a pond ecosystem decreases in the following order :

Phytoplankton → Zooplankton → Fishes → Snakes

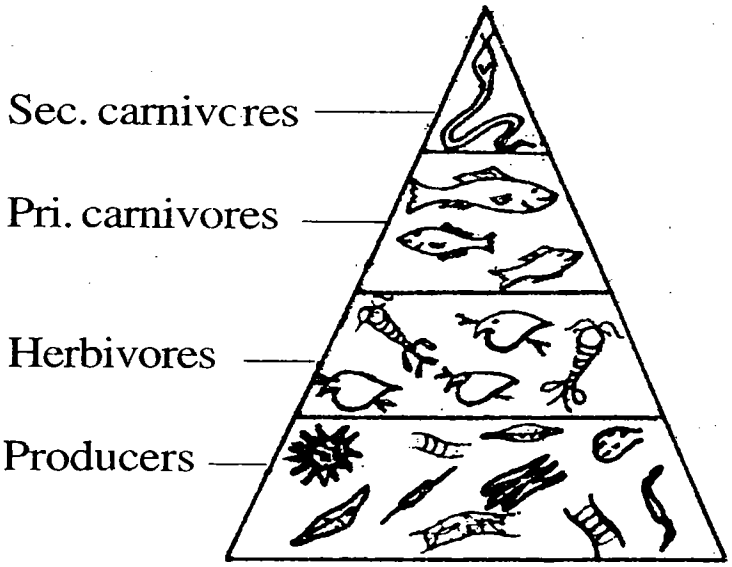


Fig.11.15: Pyramid of numbers in a pond ecosystem.

2. The Pyramid of Biomass

Biomass refers to the total weight of living matter per unit area. In an ecosystem, the biomass decreases from the producer level to the consumer level.

In a Grassland: In a grassland, the biomass of grasses is the maximum and it gradually decreases towards the consumer level in the following order:

Grass → Mouse → Snake → Hawk

Grass → Grasshopper → Lizard → Hawk

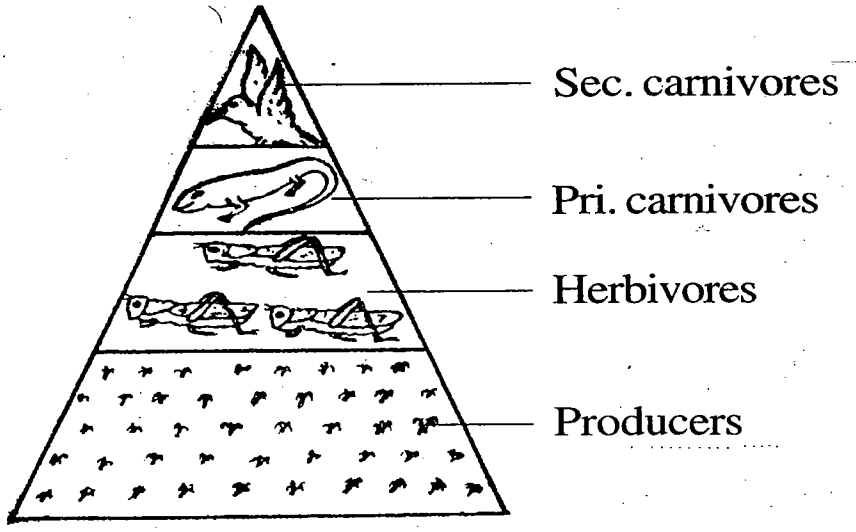


Fig.11.16 : Pyramid of biomass in a grassland ecosystem.

In a Forest : In a forest, the biomass of trees is the maximum and the biomass of the top consumer is the minimum. The decrease in weight occurs in the following order:

Plants → Deer → Fox → Tiger

Plants → Rabbit → Fox → Lion

3. Pyramid of Energy

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

In a Grassland: In a grassland, green plants trap the maximum light energy. The energy gradually decreases towards the top consumer level.

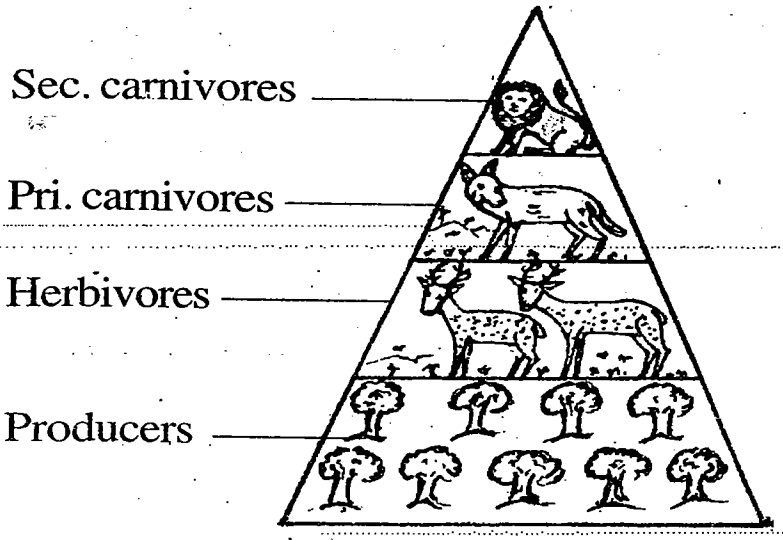


Fig.11.17: Pyramid of energy in a forest ecosystem.

Grass → Grasshopper → Lizard → Hawk
Grass → Rabbit → Fox → Lion
Grass → Mouse → Snake → Hawk

In a Pond: In a pond, maximum energy is trapped by the phytoplankton. Then the amount of energy decreases towards the top consumer level.

Phytoplankton → Zooplankton → Fish → Snake
Phytoplankton → Zooplankton → Small fish → Large fish

Inverted Pyramids

In most of the ecosystems, the number and biomass of producers are more and those of consumers are less. This type of ecosystem has a pyramid where the apex is pointed upwards. This type of pyramid is called ***upright pyramid***.

In some ecosystems, the number and the biomass of the producers are less and those of consumers are more. This type of ecosystem produces a pyramid where the apex is directed downwards. This type of pyramid is called ***inverted pyramid.*** Inverted pyramid occurs in numbers and biomass. The pyramid of energy is always upright.

Inverted Pyramid of Numbers

When the ecosystem contains lesser number of producers and more number of consumers, the pyramid will be in-

verted in shape. Inverted pyramid occurs in a tree ecosystem.

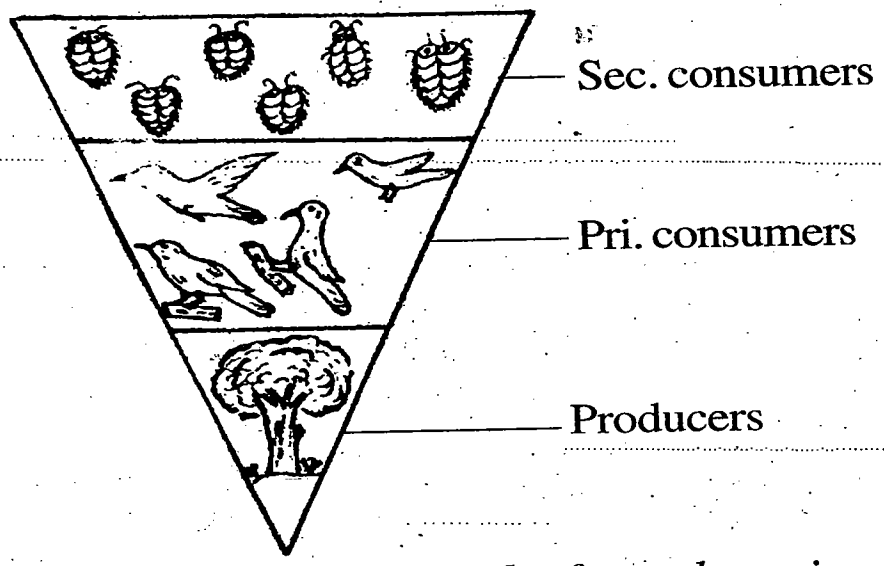


Fig.11.18: Inverted pyramid of numbers in a tree ecosystem.

A single tree (producer) contains many fruit eating birds (primary consumers). The birds contain numerous parasites (secondary consumers).

Inverted Pyramid of Biomass

When the biomass of producers is less and that of consumers is more the pyramid will have inverted shape.

It occurs in a pond or lake ecosystem. Here the biomass of diatoms and phytoplankton are negligible as compared to that of crustaceans and small fishes.

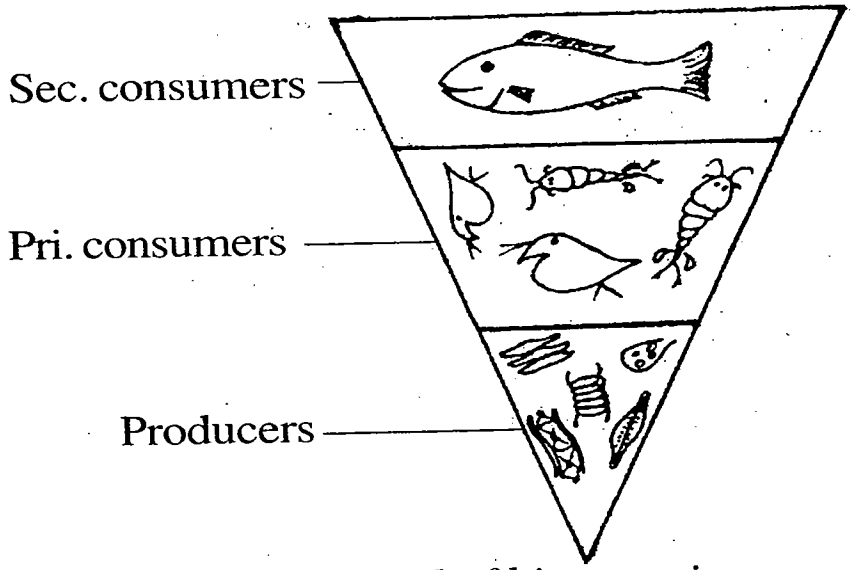


Fig.11.19: Inverted pyramid of biomass in a pond ecosystem.

Pseudomonas. These bacteria utilize the O_2 present in the nitrate for the oxidation of carbohydrate.

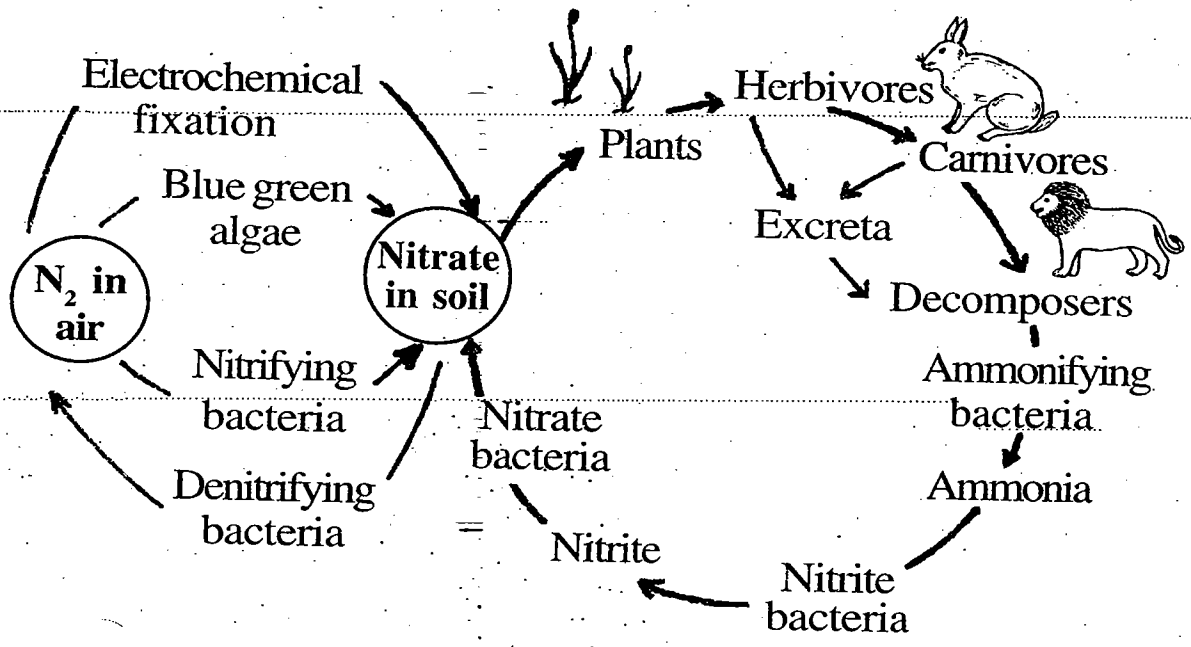


Fig.12.2: Nitrogen cycle.

D. Sedimentation

Some amount of nitrate is lost from the ecosystem by sedimentation.

3. Oxygen Cycle

The cycling of O_2 between biotic and abiotic systems is called **O_2 *cycle*.** It is a gaseous cycle. Air is the reservoir for O_2. O_2 enters the biosphere through respiration. The O_2 taken into the body is used for ***oxidation*** of carbohydrates, proteins and fats. Certain amount of O_2 in atmospheric air is converted into ozone (O_3). The ozone forms an umbrella like layer in the outer atmosphere. This layer prevents the ultraviolet radiations from reaching the earth's surface.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

$$O_2 + O \longrightarrow O_3$$

Carbon monoxide is released from volcanoes. This CO is unstable. It combines with O_2 to form CO_2.

O_2 combines with a variety of elements to form compounds. For example, it forms CO_2 with carbon, water with hydrogen, nitrates with N_2, ***ferric oxide*** with iron, etc. O_2 returns to air by

two main methods, namely ***photosynthesis*** and ***photodissociation.***

$$O_2 + C \longrightarrow CO_2$$
$$O_2 + 2H_2 \longrightarrow 2H_2O$$
$$O_2 + N_2 \longrightarrow NO_3$$

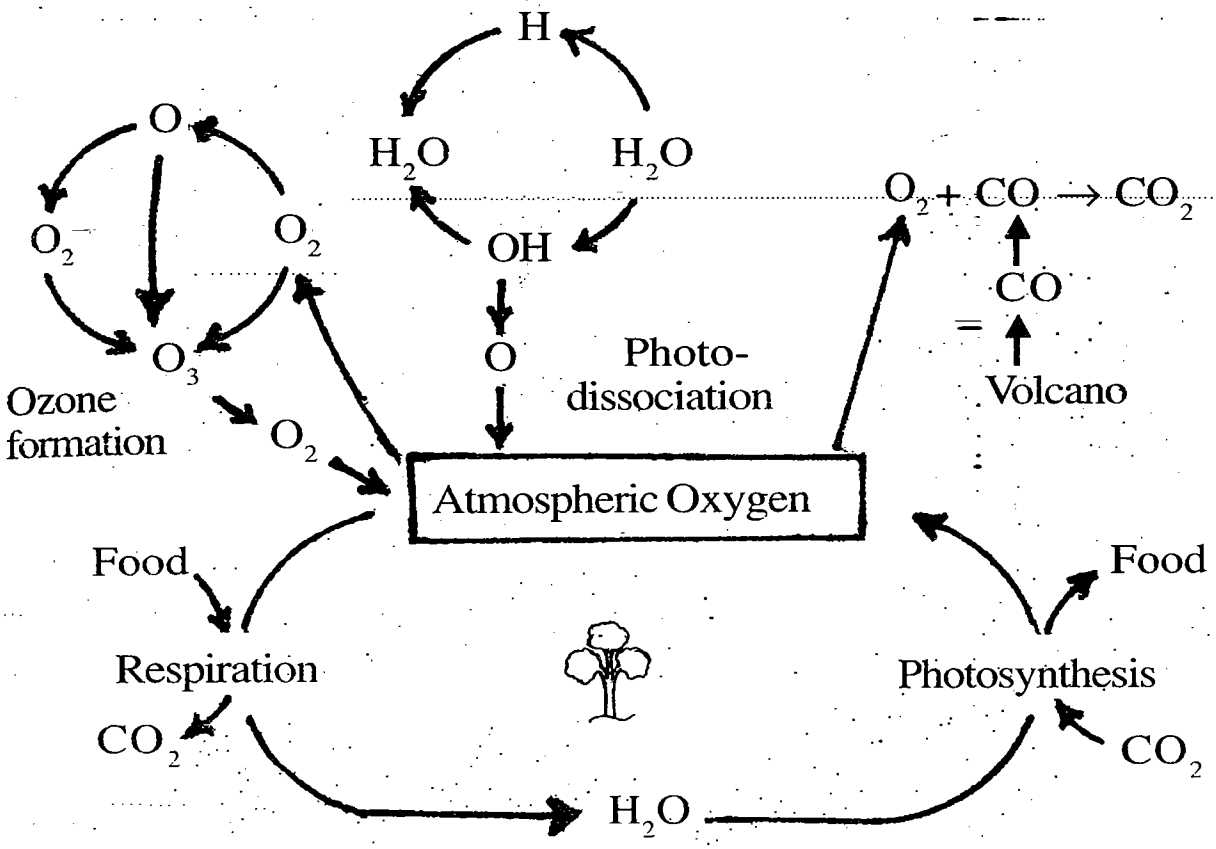


Fig.12.3 : Oxygen cycle.

1. Photosynthesis

Green plants synthesize carbohydrate by photosynthesis. During photosynthesis water molecules break up into hydrogen and O_2 is released into the atmosphere and H_2 is trapped and turned into carbohydrates.

$$12H_2O + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6H_2O + 6O_2.$$

2. Photodissociation

Water vapour is dissociated to release H_2 and O_2.

4. Phosphorus Cycle

The cycling of phosphorus between biotic and abiotic system is called ***phosphorus cycle***. It is a sedimentary cycle

Phosphorus is an important mineral nutrient. The main source of phosphorus is rocks. Through erosion and weathering phosphorus is made available in the soil. Plants absorb ionic phosphate through roots. In plants, it is incorporated into the protoplasmic components like DNA, RNA, AMP, ADP, ATP, GDP, GTP, NADP, phospholipids, etc. From plants, it passes into herbivores and animals, the organic molecules containing phosphate are decomposed and phosphate is liberated as inorganic ionic phosphate. It is again used by plants.

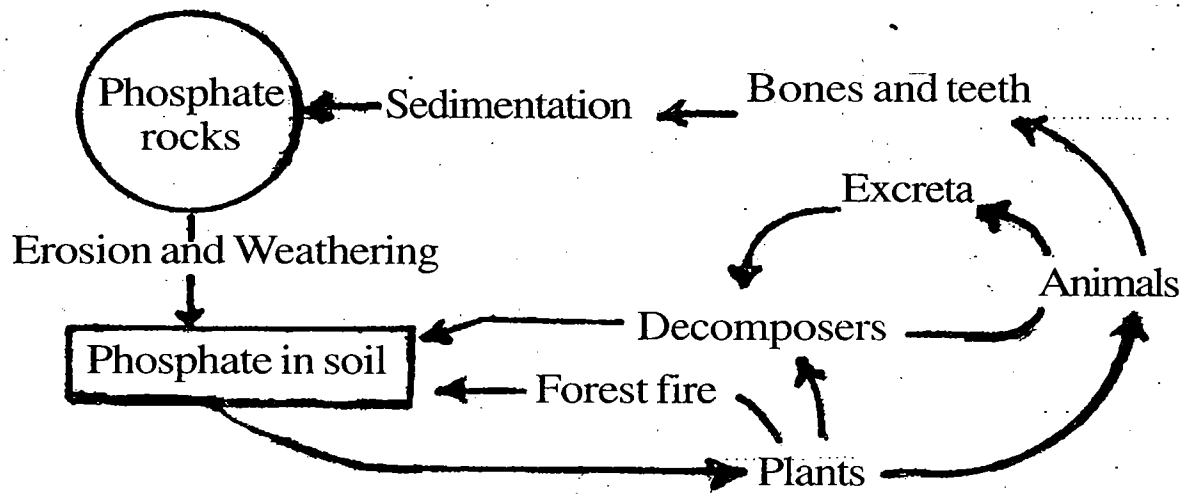


Fig.12.4 : Phosphorus cycle.

The excess of phosphate in the bodies of animals is excreted out through faeces. The bird guano (excreta) contains a large amount of phosphate.

Phosphate is also released to the soil through the combustion of forest trees and grasses.

A large amount of phosphate is lost in the sea by sedimentation. A certain amount of phosphorus gets locked in bones and teeth.

5. Sulphur Cycle

The cycling of sulphur between biotic and abiotic systems is called ***sulphur cycle***. It is a sedimentary ***cycle***. Sulphur is an important component of proteins and amino acids.

Sulphur exists in a number of states. Of these, three are important. They are elemental sulphur, sulphides and sulphates. Sulphur is present in rocks. It is made available for plants in the

form of inorganic sulphate by weathering and erosion. Sulphur passes into the animals through food chain. By the death of plants and animals, the decomposers again bring the sulphur to the soil for the use of plants.

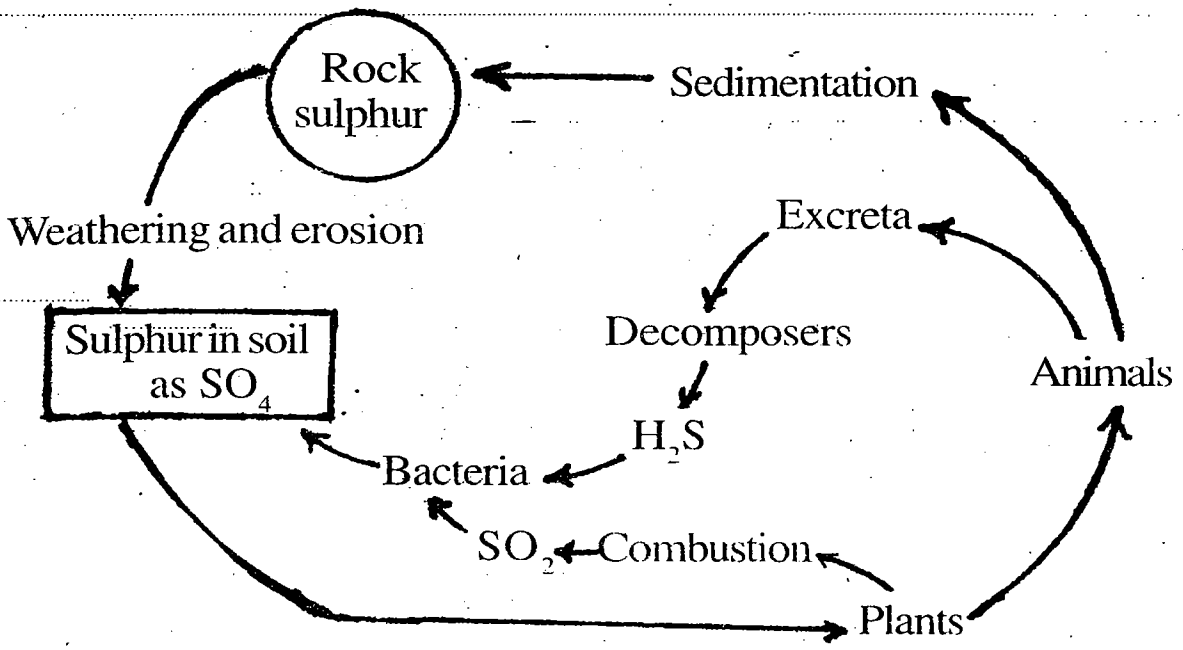


Fig.12.5: Sulphur cycle.

Some sulphur in dead bodies is released into the air as hydrogen sulphide (H_2S) by the bacteria called *Escherichia coli* under anaerobic combustion. Similarly incomplete combustion of fossil fuel releases sulphur dioxide (SO_2) into the air.

Certain bacteria (green and purple photosynthetic bacteria) oxidize H_2S of air to sulphate which can be used by plants.

$$H_2S + 2O_2 \longrightarrow SO^-_4 + 2H^+$$

Certain amount of sulphur is lost in the sediments. If iron is present in the sediments, sulphur combines with it to form iron sulphide.

$$Fe + S \longrightarrow FeS$$

populations. All the species in a community are integrated together. The community has certain characteristics and functions more than those of the populations.

2. Individualistic Concept

This concept was proposed by ***Gleason*** (1926). It considers the species as the essential units of the community. Each species behaves independently and responds to the physiological and biotic environment according to their own genetic characteristics. They are not integrated together. *The community is a collection of species requiring the same environmental conditions.*

10. Ecological Succession

The process of development of new communities is called ***ecological succession***.

It can be defined as *"an orderly and progressive replacement of one community by another till the development of a stable community in that area" (**Smith,** 1965).*

The communities in any area are not stable. They are changing into other forms of communities from time to time. Thus in a particular area one community may be replaced by another community or by a series of communities.

For example, a pond community can be transformed into a marshyland community, if the pond is gradually filled with sand and mud. The marshyland in the course of time may give rise to a grassland community or a forest community according to the environmental factors prevailing there.

Ecological succession is directional and predictable.

The succession is caused due to the modification of the physical environment.

There is an increase in structural complexity during succession.

The kinds of animals and plants change continuously with succession.

The diversity of species tends to increase with succession. But the micro-organisms and heterotrophic animals reach their maximum diversity in the later stages of succession.

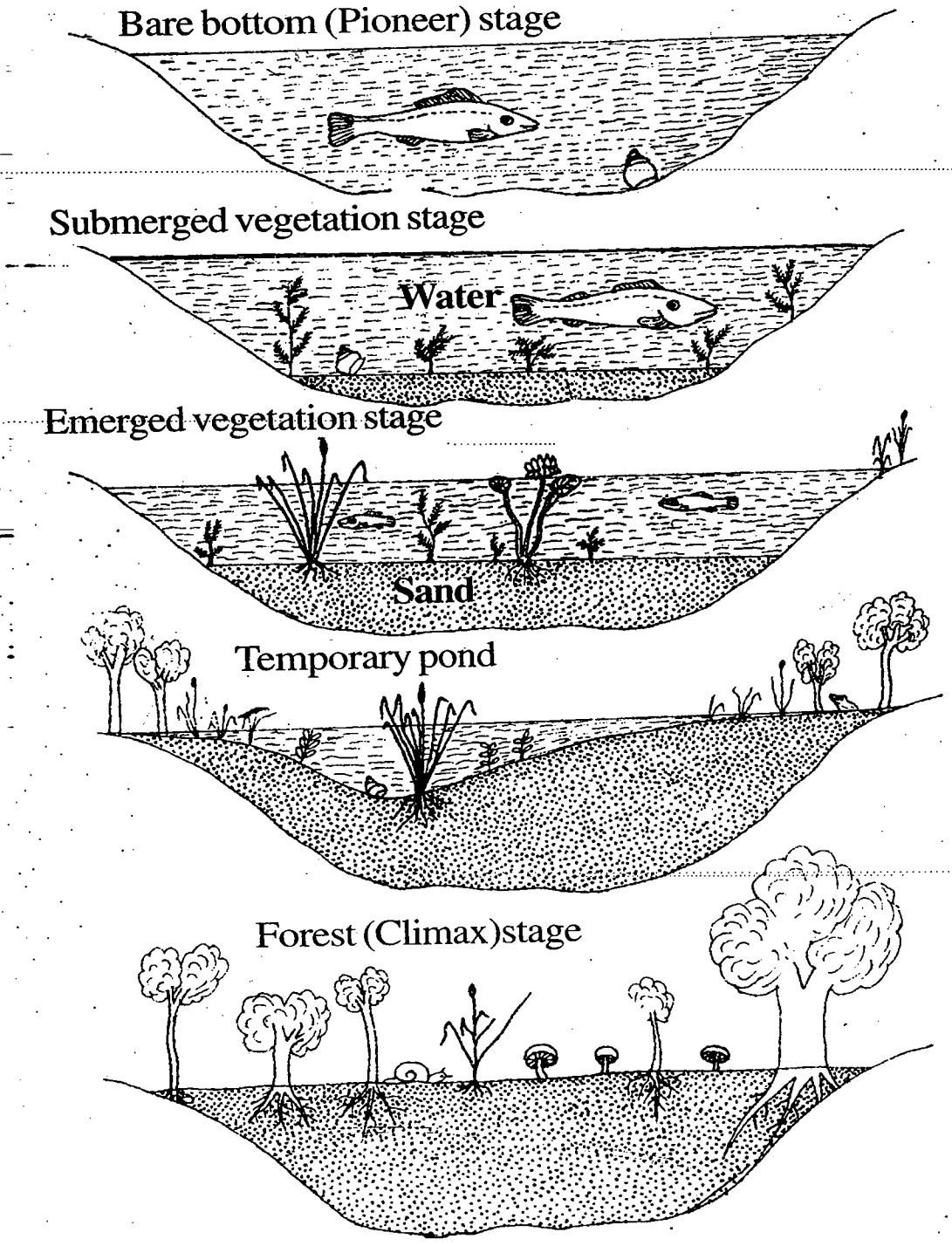


Fig.10.9: Ecological succession. A pond community is replaced by a forest community through ecological succession.

Biomass increases.

As biomass increases, many new habitat niches are created.

The succession of a community can be compared to the embryogenesis of an organism.

In the development of a community, a series of communities develop and they replace one another in an orderly sequence until the stable community is produced.

The various developmental stages of a community are called ***sere*** and each stage is called a ***seral*** stage.

The first seral stage is called the ***pioneer community.***

The final stable community is called ***climax community***.

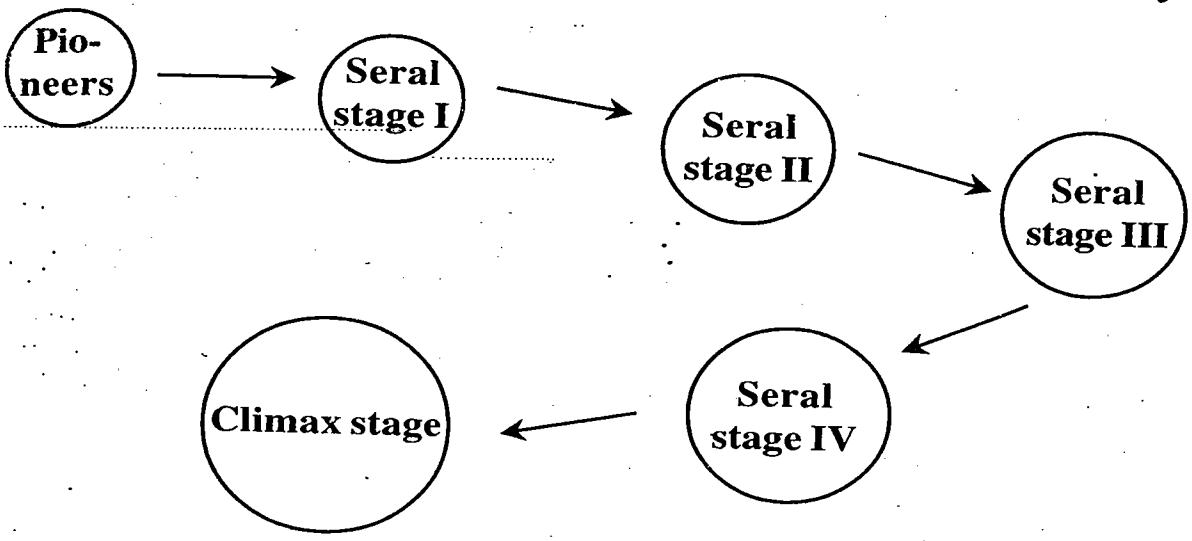


Fig.10.10: Diagrammatic representation of ecological succession.

Climax

The final stage of succession of a community is called ***climax.*** Climax is a ***stable community.*** It is self-perpetuating and in equilibrium. There are three main concepts regarding climax. They are 1. *Monoclimax theory*, 2. *Polyclimax theory* and 3. *Climax pattern theory.*

1. Monoclimax Theory : This concept was proposed by ***Clements***. According to this concept, each climatic or geographical region has only one climax community.

2. Polyclimax Theory : This theory was proposed by ***Tansley***. It says that each area is occupied by many climax communities. They are controlled by many environmental factors such as soil moisture, soil nutrients and several other factors. As there are several environmental factors, many climax communities are established.

3. Climax Pattern Theory : This theory was proposed by ***Whittaker*** (1953). According to this theory, the climax community of an area is determined by the total environmental factors of the area in which it exists. According to him, nine major factors are involved. They are the genetic structure of each species, climate, soil, site, biotic factors, fire, wind, the availability of species and the chances of dispersal.

Types of Succession

Ecological succession can be classified into two types, namely ***primary succession*** and ***secondary succession.***

1. Primary Succession

If community development starts on a sterile area which has not been occupied by any community previously, the succession is called ***primary succession.*** Example : The colonization on a newly exposed island. The first group of organisms which initiate ecological succession is called ***pioneer community.***

The development of a community on a rock is another example of primary succession. The rock is, first of all, invaded by lichens, the pioneer communities. In course of time moss appears and the moss is followed by herbs and shrubs and finally by trees.

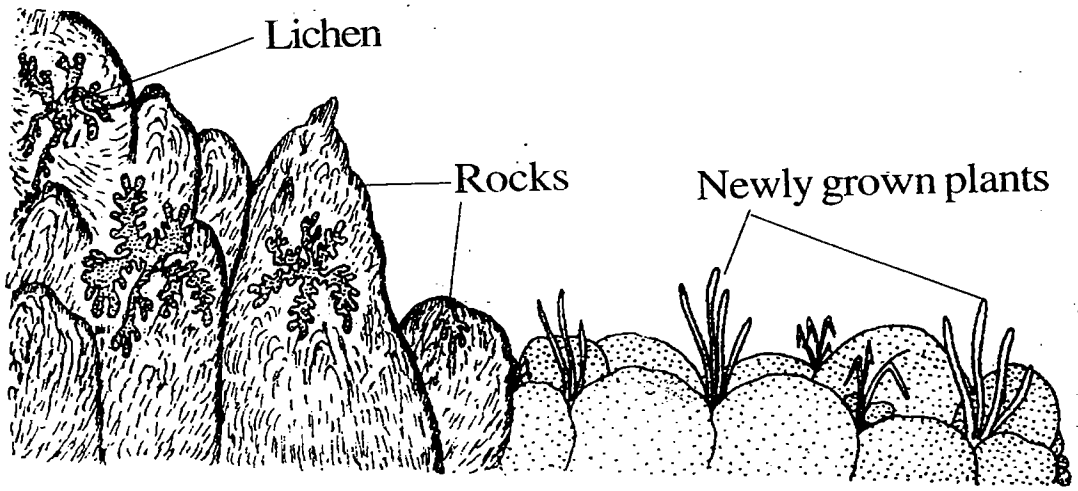


Fig.10.11: Primary succession on an island.

2. Secondary Succession

When community development starts on sites previously occupied by well developed communities, the succession is called ***secondary succession***. The development of communities in cut-over forests, abandoned crop lands and ploughed fields are examples of secondary succession.

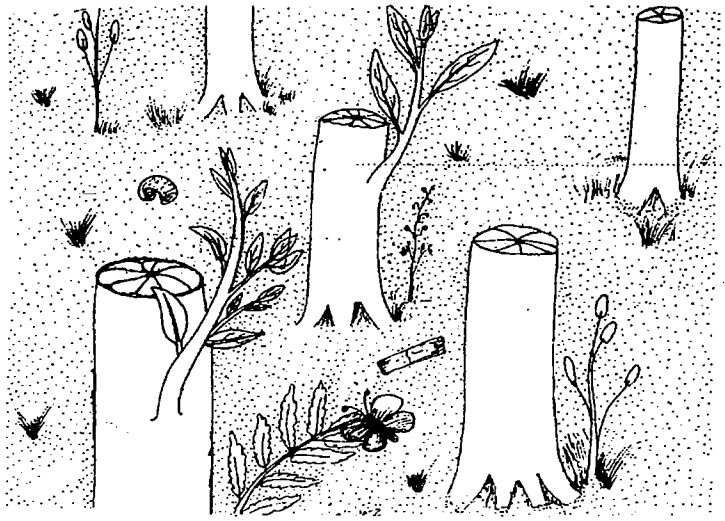


Fig.10.12: Secondary succession in a forest.

Further, based on the dominating species in the community, succession is classified into two types, namely ***autotrophic succession*** and ***heterotrophic succession***.

3. Autotrophic Succession

It is characterized by the dominance of autotrophic organisms (plants). The succession begins predominantly in ***inorganic environments***.

4. Heterotrophic Succession

It is characterized by the dominance of heterotrophic organisms (animals). The succession begins in ***organic environments.***

Patterns of Succession

Based on the place where succession occurs, three different patterns of succession, can be recognized. They are :

1. *Xerarch* or *xerosere*
2. *Hydrarch* or *hydrosere* and
3. *Mesarch* or *mesosere.*

1. Xerarch or Xerosere

When succession begins on a dry place, it is called ***xerarch*** or ***xerosere***. Succession starting on rocks is an example of xerarch. The pioneer community on rocks will be ***lichens***. In course of time lichens disintegrate the rocks and sand begins to appear. As sands are formed, ***mosses*** begin to appear. Then ***herbs*** and ***shrubs*** come to exist. These are followed by ***trees*** which form the forest community.

2. Hydrarch or Hydrosere

When succession starts in water, it is called ***hydrarch*** or ***hydrosere***. Hydrarch succession starts in a newly built pond. First of all, the pond is filled with water. The first organisms to inhabit the pond are the plankton which form the pioneer community. The plankton include ***phytoplankton*** and ***zooplankton*** like *Paramecium, Amoeba, Euglena,* etc.

Then submerged plants like *Vallisneria* and *Utricularia* and floating plants like *Nymphaea, Nelumbium, Lemna,* etc. appear. The plankton and plants enrich the pond with organic matter by their death. The thick growth of vegetation invites nymph of dragon flies, may flies and crustaceans like *Gammarus, Daphnia, Cyclops, Cypris,* coelenterates like *Hydra,* beetles, snails, frogs, etc. These are followed by carnivorous fishes, snakes, turtles, etc. Thus a climax pond community is produced.

When there is flood, water brings in silt and the silt is deposited at the bottom. So the pond becomes gradually shallow. As the water becomes shallow, the submerged aquatic plants will be displaced by floating rooted aquatic plants. Later the rooted plants are replaced by emergent aquatic plants like *Typha, Sagittaria, Rumex,* etc. With the advent of emergent plants, dragon flies and may flies begin to make their appearance. Lung breathing snails appear. Birds like heron, kingfisher, ducks, etc. appear.

As more and more silt is deposited, the area becomes a marsh land occupied by marshy plants. Then the marsh land becomes dry and all the aquatic animals disappear completely. Small species of trees appear. This is followed by large trees.

Thus a forest is formed. Then forest animals appear forming a climax forest community.

3. Mesarch or Mesosere

Mesarch succession is intermediate between xerarch and hydrarch. This succession occurs in places with moisture. It occurs in the process of hydrarch or xerarch.

Significance of Succession

1. Ecological succession creates a stable community in the fluctuating physical environment. The stable or climax community has the ability to buffer and control the physical forces like water, temperature, etc.

2. It plays an important role in the slow dispersal of animals.