

TUMKUR  UNIVERSITY

**SREE SIDDAGANGA COLLEGE OF ARTS,  
SCIENCE AND COMMERCE, BH ROAD,  
TUMKAURU.**

Department of Zoology

**VI SEMESTER**

**Environmental Biology & Ethology**

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### Syllabus:

1. Introduction, subdivisions and scope of ecology.
2. Concept of Habitat and Niche: Habitat- Definition, microhabitat and macro habitat. Niche- Definition, types- Spatial, trophic and multidimensional.
3. Abiotic factors- Principles of limiting factors, Liebig's law of minimum, Shelford's law of tolerance, combined law concept.-2 hours.
4. Ecological factors: Temperature- Thermal stratification, range of tolerance, Poikilothermy, Homeothermy. Light: Distribution, ecological effects, photoperiodism and bioluminescence.
5. Energy flow in ecosystem: Concept of productivity, laws of thermodynamics.
6. Population ecology: Population density, natality, mortality, population growth, biotic potential, population regulation and human population explosion.
7. Community ecology: Intra and inter specific interactions\_ Neutral (Neutralsim), Positive (Mutualism, proto co-operation and commensalism) and negative (antibiosis, exploitation and competition).
8. Pollution: Definition, types, water, air pollution with reference to industrial, thermal, organic and inorganic pollutants.
9. Radiations and chemical hazards: Thermal power projects, measures of disposal, ozone layer, green house effect, global warming.
10. Wild life conservation and management: Red data book, Endangered species, Major wild life sanctuaries, national parks of India. Major organizations involved in wild life conservation, Chipko and Appiko movements.

Energy flow, Food chain, Food web, Ecological pyramid

### 1. Introduction:

Man has been using natural resources without clear cut understanding of intricacies of nature and hence is facing lot of problems like pollution, green house effect, global warming etc. Today the most essential things for living like air, water and land are being polluted or destroyed beyond repair. Therefore it is important to learn the inter relationship and interdependence between the living and non-living components of nature.

Environmental biology or ecology studies this interrelationship and interdependence present in nature. The term ecology comes from two Greek words namely *oikos* means home and *logos* meaning to study. Therefore ecology is basically a branch of biology that studies the organism at home (planet earth).

Ecology is defined as the study of the total relations of all organisms to their organic and inorganic environment.

Odum defines ecology as 'the study of structure and function of nature'.

### Subdivisions:

Important subdivisions of ecology are as follows:

1. Plant ecology: It is the study of plants in relation to their environment.
2. Animal ecology: It is the study of animals in relation to their environment.
3. Habitat ecology: It is the study of living organisms in relation to their habitat.

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4. **Freshwater ecology:** It is the study of organisms present in freshwater bodies like ponds, lakes, rivers, streams etc.
5. **Marine ecology:** It is the study of organisms present in marine environment like seas and oceans.
6. **Estuarine ecology:** It is the study of organisms present in estuarine points.
7. **Terrestrial ecology:** It is the study of organisms and its environment present in terrestrial habitats like grass land, desert, cropland etc.
8. **Microbial ecology:** It is the study of microorganisms in relation to their environment.
9. **Palaeoecology:** It is the study of environmental conditions of extinct organisms.
10. **Space ecology:** It deals with the study of the environment of cosmonauts in the space ships and outer space.
11. **Radiation ecology:** It deals with the effects of radiation and radioactive substances.
12. **Autecology:** It is also known as ecology of individuals. Autecology deals with the study of an individual organism or an individual species. It studies the role of an individual in an ecosystem and also the influence of the surrounding environment on it. The subjects like Agriculture, Horticulture, and Economic botany are largely dependent on the study of autecology.  
Autecology helps in understanding the distribution, adaptation and heredity of a specific species. For example the autecology of wheat, Ragi, maize studies the methods of germination, flowering, pollination, formation and dispersal of seeds etc.
13. **Synecology:** It is the ecology of biological communities. Synecology deals with the study of groups of organisms, which are associated together as a unit. In nature different plants, animals and microorganisms live together and interact upon each other in several ways. Such complex group of organisms which are interrelated and interdependent are known as community. Therefore in synecology community forms the unit of study. For example forest community, grassland community etc. Synecology helps in understanding of the complex interrelationship and interdependence between living and nonliving components of nature.

#### Scope of ecology:

1. It helps in creating environmental consciousness among people.
2. It provides knowledge for the proper maintenance of natural resources.
3. It helps in understanding the harmful effects of pollution.
4. It helps in understanding the need for controlling the pollution.
5. It helps in understanding the delicate balance present between living and nonliving components of nature.
6. It helps in understanding the process of evolution.
7. It helps in discovering new sources of food and energy.
8. It helps man to take suitable steps to prevent the extinction of species and different ecosystems.
9. It helps in getting jobs as environmental officers, research scientists and clean technology entrepreneurs.

#### 2. Concept of Habitat:

**Habitat:** Habitat is a place where an organism lives. Usually one of the abiotic component forms the controlling and limiting factor. Depending on the kind of habitat, the ecology has a number of branches. The branch of ecology that studies the habitat is called habitat ecology. It may have several sub branches like freshwater ecology, marine water ecology and terrestrial ecology.

Odum compares the habitat to the place where an organism lives. He refers the habitat of an organism to its address. There are two types of habitats namely microhabitat and macrohabitat.

Microhabitat is a place where a particular type of organism can only survive and live. In microhabitat two different species cannot exist for long time. There will be severe competition between the individuals or the species to occupy the microhabitat. For example the epiphytes present in the forest. Different species of millipedes living under the bark of the tree.

Macrohabitat is a place where an organism lives. It may be surrounded by many other organisms in the same place. For example forest is the habitat for Tiger, Elephant, Grasshopper etc. However there will not be any competition or severe struggle between these organisms.

Niche:  
The word niche is used in different contexts in ecology. Odum has compared the habitat of an organism to its address and its niche to its profession in the community. Elton refers niche to the functional status of the organism in the community. Odum describes the meaning of ecological niche in 3 divisions. They are

1. Habitat niche
2. Trophic niche and
3. Hyper volume niche.

#### 1. Habitat niche (Spatial niche):

The habitat niche or spatial niche represents the ultimate distributional or spatial unit occupied by a species. The habitat includes the space for many species. The habitat or spatial niche provides the space only to a particular species. It is equivalent with microhabitat. For example there are 7 species of millipedes living in the forest floor. They are all detritus feeders. But each one of them occupies a particular microhabitat.

#### 2. Trophic niche:

It refers to the functional status of an organism with reference to the trophic level. Two different species may live in the same habitat, but they occupy different trophic niches because of different food habits. For example deer and lion may have the same habitat namely forest but deer is a herbivore and lion is a carnivore.

#### 3. Hyper volume niche (Multidimensional niche):

Each community or species lives in aggregation of many environmental and functional variables. For example a sparrow can feed on insects, which fly above 40 feet or insects present on the ground. However they may prefer the insects that fly at a particular height. Thus there are infinite dimensions for a species among complex variables present in the ecosystem.

#### Advantages of ecological niche:

1. The organisms avoid competition by occupying different niches.
2. The niche occupied by a species is favourable to it. Because it provides a suitable microhabitat.
3. Segregation of niches avoids confusion of activities between organisms in the community.
4. The spatial niches provide an opportunity for full exploitation of the available resources.

### 3. Abiotic factors

#### Principles of limiting factors

The distribution and growth of plants and animals in an ecosystem are controlled by both abiotic and biotic factors of the environment. Any factor acting to alter the growth and survival of a population is called limiting factor.

In other words any factor that tends to slowdown potential growth in an ecosystem is a limiting factor. For example oxygen is a limiting factor for aquatic organisms.

There are three laws on limiting factors namely

1. Law of Minimum ( Liebig's law of minimum).
2. Law of Tolerance ( Shelford's law of tolerance) and
3. Combined concept of limiting factors.

### 1. Liebig's Law of Minimum:

This law was proposed by Liebig (1840), a German organic chemist. He found that the yield of crops was often limited not by nutrients needed in large quantities such as Boron. Boron is needed in minute quantities but is scarce in soil. He states that "the growth of a plant is dependent on the amount of the food stuff which is presented in minimum quantities".

This law can be extended to all other organisms. Certain abiotic factors required in small quantities for growth and development of the organisms can limit the growth by their scarcity. For example boron is a limiting factor for paddy and oxygen is a limiting factor for aquatic organisms.

The law of minimum has two subsidiary principles. They are as follows:

1. Liebig's law is strictly applicable only under steady state conditions.
2. Factor interaction: The high concentration or availability of some substance or the action of same factor other than the minimum one, may modify the rate of utilization of the latter. Some times organisms are able to substitute, in part at least. A chemically closely related substance for one that is deficient in the environment. For example plants use less zinc in shade than those growing in full sunlight. Molluscs use strontium to substitute calcium.

### 2. Shelford's law of tolerance:

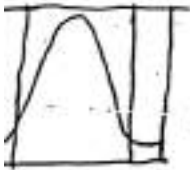
The law of tolerance was proposed by Shelford in 1913. According to this law organisms are exposed to a variety of environmental factors such as light, temperature, nutrients etc. they respond differently to the different intensities of a factor. Organisms survive well only at particular rate of intensity. This is called tolerance. The law of tolerance states that "organisms grow and reproduce well at a particular range of intensity of an environmental factor".

When the intensities are too high or too low, the organisms are intolerant and hence they are excluded from the environment. For every organism each environmental factor will have two zones namely zone of tolerance and zone of intolerance.

#### 1. Zone of tolerance:

Organisms survive well at a particular range of intensity of any environmental factor. This range is called zone of tolerance. It is further subdivided into three zones namely critical minimum zone, optimum one and critical maximum zone.

- a) Critical minimum zone: It is the lowest intensity of the factor at which the activity of the organisms slows down. It comes to a stage of dormancy due to physiological stress.
- b) Optimum zone: It is the range of intensity at which the rates of growth, reproduction and survival capacity are high.
- c) Critical maximum zone: It is the highest intensity of the factor at which the activity slows down and the organisms come to a state of dormancy due to physiological stress.



**2. Zone of intolerance:** When the intensity of an environmental factor is either too low or too high, organisms cannot survive. This high or low intensity of an environmental factor is called zone of intolerance.

#### Salient features of law of tolerance:

1. Each abiotic factor has a range of intensity at which the organisms survives well. This is called tolerance.
2. Species vary in their limits of tolerance for the same factor. For example Salmon fish survive well at high salinity and also at low salinity. But other fishes can not tolerate salinity.
3. The same species varies in its limits of tolerance of different factors. For example some freshwater fishes cannot tolerate major changes in salinity. But they can tolerate major changes in temperature.

4. Organisms with wide range of tolerance for many factors have universal distribution. For example Man, Rat, Cockroach and Mytilus are cosmopolitan in distribution.
5. The tolerance of any organism for an environmental factor can be represented in the form of a curve called tolerance curve.
6. When a species has a narrow range of tolerance, the prefix 'steno' is added to the factor. For example stenothermal, stenohaline.
7. When a species has a wide range of tolerance the prefix 'eury' is added to the factor. For example Eurythermal, Euryhaline.

### 3) Combined concept of limiting factors:

The Liebig's law of minimum and Shelford's law of tolerance are considered together to form the combined concept of limiting factors.

The organisms are exposed to a variety of environmental factors. Almost all the factors are essential for organisms. However some factors become limiting factors. These factors are characterized by minimum availability in the environment and the changes of intensity of the factors in the environment.

The survival of an organism depends on the very presence of some of the major environmental factors. For the survival of an organism, some factors are required in minimum quantity. In addition the organisms must be tolerant to the changes of the intensity of the limiting factors.

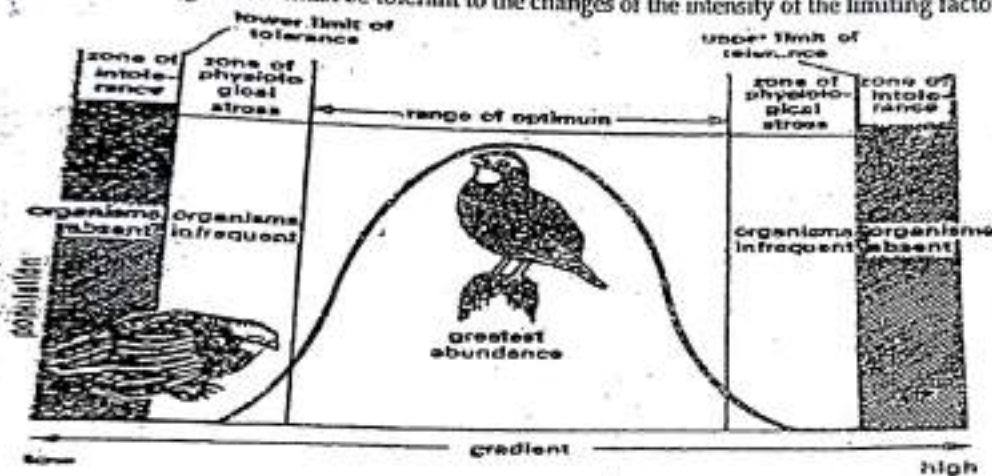


Fig. 21.2. Graphic illustration of the law of tolerance (after Smith, 1977).

Upper and lower limits of tolerance are intensity levels of a factor at which only half of the organisms can survive. These limits be sometimes difficult to determine, as for example with low temperature, organisms may pass into an inactive, dormant, or hibernating state from which they may again become functional when the temperature rises above a threshold. At high temperatures, there may be similar inactivation or aestivation before the final level is attained. Even without dormancy occurring, there

## 4. Ecological factors

### Temperature

It is an important ecological abiotic factor. It is defined as the intensity aspect of heat. It is a form of energy and is called thermal energy.

Temperature is measured either in Celsius or Fahrenheit. It influences the growth, metabolism, reproduction, distribution, movement etc.

Temperature is a variable factor. It varies from place to place and time to time. It is high at the equator and low in the Polar Regions. It is high at the sea level but low at high altitudes. It is high in the open land and low in the shady places.

The temperature fluctuates more in the terrestrial habitat. It is high during day time and low at night. At the altitudes temperature is low, for every rise of 150 meters there is a decrease of 1°C. The temperature fluctuation in an aquatic habitat is lesser than that of terrestrial habitat. The fluctuation depends on the depth and topography. Increase in depth increases the temperature.

\* **Thermal stratification:**

5<sup>m</sup> In deep freshwater habitats like 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 will be three layers namely epilimnion, thermocline and hypolimnion.

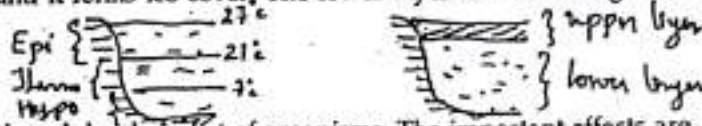
Epilimnion is the upper layer of water and is a warmer layer. The temperature in this layer fluctuates with the temperature of the atmosphere. It may range from 27 to 21°C.

Thermocline is the middle layer and is present between epi and hypolimnion. It is characterized by gradation of temperature from top to the bottom. It may have 21°C above and 7°C below.

Hypolimnion is the bottom layer. The water is cool having the temperature between 5 and 7°C.

\* **Winter stratification:**

During winter only two layers are seen namely upper layer and lower layer. The temperature of the upper layer is reduced to 0°C and it forms ice cover. The lower layer is cool having 4°C throughout.



107 → **Biological effects of temperature:**

The temperature effects on the growth and development of organisms. The important effects are as follows:

1. **Temperature tolerance:** Every organism has a particular range of temperature at which the organism thrives well. This temperature is called optimum temperature. The lowest temperature at which the organism can survive under physiological stress is called critical minimum zone or 'minimum survival temperature'. The highest temperature at which an organism can live is called critical maximum range or 'maximum survival temperature'.



Tolerance curves for eurytopic (A) and stenotopic (B) responses to a given environmental factor.

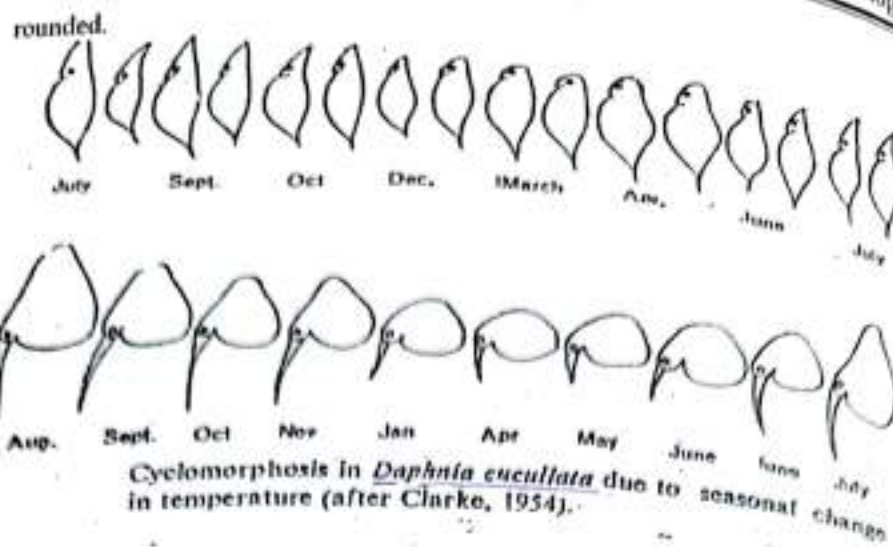
Terminology for ranges of certain abiotic environmental factors.

Stenothermal—Eurythermal	Pertaining to temperature
Stenohaline—Euryhaline	Pertaining to salinity
Stenohydric—Euryhydric	Pertaining to water
Stenophagic—Euryphagic	Pertaining to food
Stenobathic—Eurybathic	Pertaining to depth
Stenococious—Eurycocious	Pertaining to niche or habitat selection

2. **Stenothermal and eurythermal organisms:** The organisms, which can tolerate wide ranges of temperature fluctuations, are called eurythermal organisms. Ex. Man, Locust, Lizard. The organisms which can not tolerate wide range of temperature fluctuations are called stenothermal organisms. They have narrow range of tolerance to temperature. Ex. Corals.

3. **Poikilothermic animals:** In many animals, the body temperature <sup>changes</sup> according to the fluctuations of environmental temperature. These animals are called poikilothermic animals or cold blooded animals. They cannot regulate their body temperature by metabolism. But they gain temperature from environment. Therefore they are also called ectothermic animals. Ex: all animals except birds and mammals.
4. **Homeothermic animals:** In some animals the body temperature remains constant and it is independent of environmental temperature. These animals are called homeothermic animals or warm-blooded animals. They can regulate their body temperature by generating heat through metabolic activities. Hence they are also called endothermic animals. Ex: Birds and mammals.
5. **Heterothermic animals:** Some animals have limited power of regulating their body temperature. These animals are called heterothermic animals. Ex: Egg laying mammals and pouched mammals.
6. **Effect of temperature on metabolism:** The increase in temperature increases the rate of metabolism. Vont Hoff's rule states, "The rate of chemical reactions are doubled for every 10°C increase in temperature". This increase is represented as Q 10. Q10 refers to the effect of temperature.
7. **Effect of temperature on growth:** The increase in temperature increases the rate of growth. For example the oyster grows from 1.4 mm to 10.3mm when the temperature is raised from 10 to 20 °C.
8. **Effect of temperature on development:** The raise in temperature decreases the time required for hatching. For example the fish egg hatches in 150 hours at 12°C and in 50 hours at 21 °C.
9. **Effect of temperature on reproduction:** The increase in temperature increases the sexual maturity and to lay more number of eggs in insects like grass hoppers.
10. **Effect of temperature on sex ratio:** The temperature determines the sex in some animals like crocodiles, copepods etc. The males increase in number when temperature increases.
11. **Effect of temperature on colouration:** The increase in temperature leads to dark colour due to the development of melanin pigments. The animals that live in lower temperature are pale in colour. This phenomenon is called "Gloger's rule".
12. **Effect of temperature on morphology:** Temperature influences the size of the animals. The animals living in colder regions attain maximum size. For example polar bear. This phenomenon is called "Bergman's rule". The extremities of animals especially mammals like the tail, snout, ears and legs are relatively shorter in colder regions than in warmer regions. This phenomenon is called "Allen's rule".
13. **Effect of temperature on distribution:** The temperature is a limiting factor in the distribution of animals. The animals, which are stenothermal are restricted to certain parts of the earth. For example the corals are restricted to tropical seas.
14. **Cyclomorphosis:** In Daphnia, temperature influences on the shape of the body and this phenomenon is sporadically and is called cyclomorphosis. During winter Daphnia has a round head but during spring a helmet like projection develops on the head. In summer it attains maximum size. In autumn it gets reduced and in winter the head becomes again





15. **Hibernation:** Hibernation is the winter sleep during which animals undergo dormancy to escape from excessive cold. Ex: Frogs, Toads, Reptiles, and Bats. During hibernation frogs take rest in the burrows. Their energy requirement is very low. The heartbeat is reduced. The metabolic rate is reduced.
16. **Aestivation:** Aestivation is the summer sleep during which time the animals enters into a state of rest. During aestivation, the respiratory rate, heart beat and rate of metabolism is reduced. Ex: Garden Snail



Heads of arctic fox (*Alopex lagopus*), red fox (*Vulpes vulpes*) and desert fox (*Megalaris zerda*) showing gradation in size of ears and illustrating Allen's rule (after Clark, 1954).

### Light as an ecological factor:

Light is the most important abiotic factor. All plants depend on light for their energy and all animals depend on plants.

Organisms get light from the Sun, Moon, Stars, lightning Volcanoes and bioluminescent organisms.

Light is a form of energy called radiant energy. The amount of solar radiation reaching the surface of the earth is two calories per square cm per minute. It is more or less constant and is called solar constant or solar flux.

**Distribution:** The intensity of light on the earth's surface varies from place to place and from time to time. The intensity of light is low at dawn and dusk. The intensity is very high when the sun is overhead. The suspended particles like dust, clouds and smoke present in the air screen a certain amount of light. The vegetation reduces the intensity of light. At high altitudes, the

intensity of light is high. At equatorial region intensity of light is higher and it decreases near the latitude.

The light distribution in water depends on the colloidal particles, planktons and depth. On the basis of penetration of light, the water column of the oceans is divided into three zones namely Euphotic zone, Disphotic zone and Aphotic zone. The upper euphotic zone extends down to a depth of 80 meters. It is the lighted zone. The middle disphotic zone extends from 80 to 200 meters. The light is highly modified in this zone. The lower aphotic zone is without light and it extends beyond 200 meters.

Ecological effects of light:

1. **On plants:** Plants are divided into two groups namely Sciophytes and Heliophytes. Sciophytes are shade loving species where as heliophytes are light loving species. The radiant energy is used during photosynthesis. Plants grown in insufficient light produce maximum amount of growth hormone. As a result of which they are elongated with weak pale yellow stem. There are no supporting structure like xylem and phloem.
2. **Effect on development of flowers, fruits and seeds:** Diffused light promotes the development of vegetable crops like potato and carrots. Intense light favours the development of flowers, fruits and seeds.
3. **Effect on metabolism:** The intensities of light influence the rate of metabolism. The light increases the enzymatic activity.
4. **Effect on pigmentation:** The diffused light reduces the melanin pigments leading to pale colour. The intense light produces more melanin pigments and hence dark colour. For example cave animals are without colour because of absence of light. But when exposed to light, they develop colour. Similarly Indians are dark in colour because of greater expose to light.
5. **Effect on reproduction:** Light influences on the reproduction. For example the gonads of birds become more active with increase in light during summer. According to the influence of light on reproduction animals are classified into 3 types namely 1. Long day animals, 2. Short day animals and 3. independent day length or neutral animals.  
Long day animals are those, which are sexually active when the days have more duration. Ex: Birds.  
Short day animals are those, which are sexually active when the days are short. Ex: Sheep, Deer.  
Indifferent day length animals are those whose sexual activity is not influenced by light. Ex: Cow, Man.
6. **Parthenogenesis:** When sea urchin eggs are exposed to UV light and when silk moth eggs are exposed to sunlight they begin their development without fertilization. Thus light can initiate parthenogenesis.
7. **Development:** In some animals light promotes development. For example Salmon fish larvae develop normally only when there is sufficient light.
8. **Locomotion and movement:** Light influences on the movement of organisms, which may be classified as photokinesis, phototaxes and phototropism. Photokinesis is a phenomenon where the velocity of locomotion is influenced by light. For example Locusts stop their flight when clouds hide the sun. Phototaxes is a phenomenon where in the direction of movement is influenced by light. For example positive phototaxes is present in Euglena. Negative phototaxes is present in Planaria. Phototropism is a phenomenon where a part of the organism moves in response to light. For example movement of polyps of coelenterates.
9. **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. For example the birds migrate towards north when the day is long. The birds migrate towards south when the day is short. The day length also influences the sexual activity in birds. Increasing the length of the day stimulates the laying of eggs in hens. In mammals the development of fur is related to photoperiod. The reproductive activities of plants are also influenced by photoperiod. Therefore the plants are classified into 3 types.

- a) Long day plants: They are the plants that produce flowers and seeds during summer when days are long.
  - b) Short day plants: They are the plants that produce flowers and seeds during winter when the days are short.
  - c) Neutral plants: They are the plants that produce flowers and seeds without being influenced by the photoperiod.
10. Diurnal migration: The marine plankton 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 Diurnal migration > Ex: Daphnia.
  11. Circadian rhythm: It is the daily rhythm that is present in animals in relation to the light and dark period of each day. For example the animals that are active during daytime are called diurnal animals. Ex: Man. The animals that are active during nighttime are called nocturnal animals. Ex: Cockroach.
  12. Lunar rhythm: It is the cyclical event caused by the rotation of moon around the earth. It is a 29-day cycle, which includes full moon phase and new moon phase. The life activities of some animals are affected by lunar rhythm. For example pololo worm, a marine polychaete breeds twice in a year, only on full moon days. Grunion fishes living in the Californian seas breed on full moon days. They come to the shore for breeding only on full moon days.
  13. Bioluminescence: Some of the animals produce their own light and this phenomenon is called bioluminescence. A chemical called luciferin and an enzyme called luciferase are involved in the process of bioluminescence. It is commonly referred as "Cold light" because heat is not generated in this process.  
Bioluminescence helps in the following:
    - a) Identification of same species.
    - b) Identification of opposite sex.
    - c) In attracting opposite sex.
    - d) In helping to catch the food material. Ex: Antennarius.

### 5. Energy flow in ecosystem:

Energy is the capacity to do work. There are two kinds of energy namely kinetic energy and potential energy. Kinetic energy is due to motion and it results in work. Potential energy is the energy at rest and it is capable of and available for work.

The storage and expenditure of energy in an ecosystem can be described by the laws of thermodynamics.

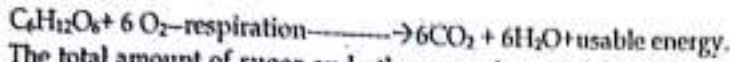
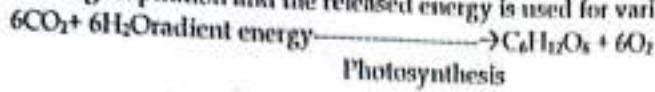
#### Laws of thermodynamics:

The first law of thermodynamics: It is also called the law of conservation of energy. It states "Energy can neither be created nor be destroyed". It may be transferred from one form to another or from one place to another.

In an ecosystem the main source of energy is the light or radiant energy of the sun. the amount of solar radiation reaching the surface of the earth is about 2 calories per square cm per minute. This is more or less constant and is called solar constant or solar flux. The plants utilize only 0.02 % of energy reaching the earth. Much of the radiant energy of the sun is lost by reflection.

3<sup>1</sup> Second law of thermodynamics: It states "Whenever energy is transformed from one form to another, there is increase in entropy and a decrease in the amount of useful energy". When one form of energy is converted into another form some amount of energy is not available and it is lost in the form of heat. The measure of this relative disorder that takes place during energy transformation is called entropy.

In ecosystem plants convert radiant energy into chemical energy in the form of sugar by means of photosynthesis. The sugar molecules may be converted into starch, cellulose and may combine with other substances to form nucleic acids, proteins, hormones etc. Some amount of sugar is oxidized during respiration and the released energy is used for various metabolic activities.



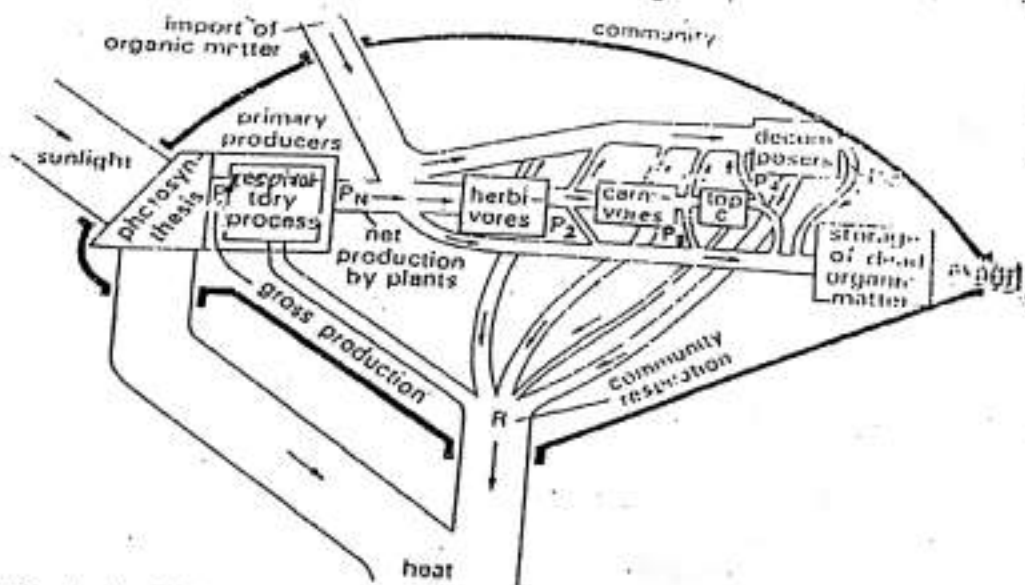
3 The total amount of sugar and other organic materials produced in plants per unit area per unit time is called gross primary production (GPP).

Some amount of sugar is oxidized during respiration. Therefore it is not easy to measure gross primary production. The total organic material (biomass) that is actually present is called net primary production (NPP).

$$\text{NPP} = \text{GPP} - \text{Respiration.}$$

Thus the total amount of organic material produced by plants during a given period of time per unit area is called primary production. It is usually expressed in terms of grams or kilos.

The energy stored by the plants is utilized by the herbivores. They eat only few parts of the plants and convert the energy into the chemical energy in the tissues. The total amount of energy stored in the tissues of herbivores is called secondary production. Here also there is gross secondary production and net secondary production. Only about 10-20% of primary production is converted into secondary production. The remaining 80-90% of energy is lost due to respiration, excretion, unassimilation etc. Similarly the energy flows from primary consumers to secondary consumers and secondary consumers to tertiary consumers. Finally the energy flows from dead plants and animals to the body of decomposers. The decomposers convert the remaining organic energy into heat. Thus the energy flow in an ecosystem is unidirectional and during the transformation of energy from one trophic level to another 80-90% of energy is lost representing entropy. Thus the energy flow in an ecosystem follows the laws of thermodynamics.



The relationship between flow of energy through the grazing food chain and detritus pathway. (After E.P. Odum, 1956).

## 6. Population ecology

The study of populations and their interactions with the other living and nonliving components of the environment is called population ecology. Population refers to a group of organisms of the same species living in a particular area at a given time. Population has certain characteristics like density, natality, mortality, population growth, biotic potential, population regulation etc.

Population density:

It refers to the total number of individuals in a unit area or unit volume at a given time. It may be expressed in various parameters. For example number of bacteria in a liter of water, number of plants per hectare of land, number of people per square kilometer.

The population density of any population can be expressed by the following formula.

$$D = \frac{N}{a \cdot T} \quad \text{where } D = \text{density, } N = \text{number of animals } T = \text{time and } a = \text{area.}$$

There are 4 methods to measure the population density. They are total count, sampling method, tagging method and pellet counting method.

1. Total count: In this method all the individuals are counted one by one. It is the direct method and gives accurate density. But it is possible only in case of plants.
2. Sampling method: In this method suitable samples are selected and organisms per sample are counted. Then the density is calculated by extrapolation. The sampling units may be in the form of quadrates (squares) or transects (rectangles) or circles. For example the density of trees in a forest is measured taking samples. Each sample having 50 square meters for large trees or 5 square meters for the grass.
3. Tagging method: This method is used to count larger animals like birds, fishes, squirrels etc. In this method a definite number of animals say about 100 are captured, marked and released. After some days another set of animals are captured (100). In this group the tagged and untagged animals are counted. The ratio is extrapolated to get the correct population density.
4. Pellet counting method: In this method faecal pellets in an area are counted. The population size is calculated from this by knowing the average rate of defaecation. This method is used for mice, hares and rabbits.

2. Natality or birth rate: Natality or birth rate refers to the average number of new individuals produced by a population in a given time. Natality is due to the production of seeds, germination, fission or hatching or birth. The size of the population increases with the increase in birth rate. There are two kinds of natality namely potential natality and realized natality.

Potential natality is the maximum possible rate of reproduction for a population under optimal conditions. It is also referred as maximum natality. For Salmon fish produces 28 million eggs in a season. A female round worm produces 7 lakhs of eggs per day. However all the eggs do not hatch and reach adulthood because of environmental resistance. Hence potential natality is not attained in nature.

Realized natality refers to the actual number of new individuals added to the population in a given time. It is also referred as ecological natality. Realized natality is considerably lesser than the potential natality.

$$\text{Natality or birth rate} = \frac{\text{Number of births per unit time}}{\text{Average population}}$$

The birth rate indicates the reproductive ability of an organism and also the survival efficiency of the organism. The increase in natality indicates the success of the species. The decrease in natality indicates the problems that the species is facing in the environment.

3. Mortality or Death rate: Mortality refers to the number of individuals dying in a population at a given time. The size of the population decreases because of the population of mortality.

There are two kinds of mortality namely potential mortality and realized mortality.

Potential mortality refers to the number of deaths due to old age. It is also referred as minimum mortality.

Realized mortality refers to the actual number of deaths that occur in a population. The death may be due to environmental factors like predation, diseases, accidents and other hazards. Realized mortality is always higher than the potential mortality.

$$\text{Mortality or death rate} = \frac{\text{Number of deaths per unit time}}{\text{Average population}}$$

The ratio between the birth rate and death rate is called vital index. It is represented by the formula:

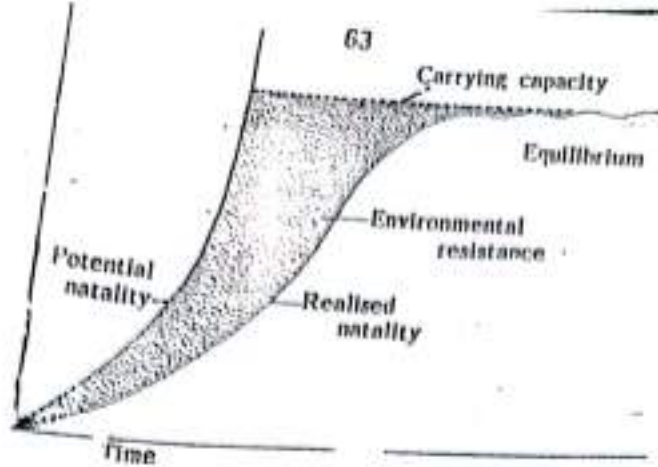
$$\text{Vital index} = \frac{\text{Birth rate}}{\text{Death rate}}$$

The vital index helps to understand the rate of growth of population. When the birth rate is higher, the population grows progressively. When the death rate is higher, the population declines. When the birth rate is equal to the death rate, the population is stable and it remains at equilibrium.

Population growth: The increase in the size of population is called population growth. A population grows when the birth rate is high and death rate is low. It is also aided by the immigration that is migration of animals into the population from another similar population.

The increase in the number of animals can be plotted against time factor to get a curve called growth curve. The pattern of growth curve is different for different populations. However two patterns of growth curves are significant. They are "S" shaped growth curve and "J" shaped growth curve.

1. 'S' shaped growth curve: When a few organisms are introduced into an unoccupied area, the population there grows gradually. In the beginning, the growth is slow. This stage is called positive acceleration phase. Then the growth is rapid and the population increases steeply. This stage of growth is called logarithmic phase. After reaching the maximum size, the growth rate slows down due to environmental resistance. This stage is called negative acceleration phase. After this the population reaches an equilibrium level in which there is neither increase nor decrease. This pattern of growth curve is exhibited by the yeast and bacterial growth in the laboratory.
2. 'J' shaped growth curve: In certain populations, the growth is very rapid. The number of organisms increases just like compound interest. Then the growth stops abruptly and the population declines suddenly. The decline is caused by environmental factors. This type of growth pattern gives a 'J' shaped curve. It is exhibited by Lemmings, Algal blooms etc. the upper level beyond which no more increase in a population can occur is called carrying capacity. The carrying capacity is defined as the maximum individuals of a population that can be supported in a habitat at a given time. Once the population reaches the carrying capacity, it fluctuates around it till it reaches the equilibrium.



### **Biotic potential:**

Biotic potential refers to the actual growth of the population in the existing favourable conditions. It is the inherent ability of a population to increase in number when the age ratio is stable and all environmental conditions are favourable.

Mathematically it may be defined as the slope of the population growth curve during the logarithmic phase of growth. It is reduced when the environmental conditions are not optimum. The factors, which prevent the population from reproducing to its maximum, are called environmental resistance. It includes both abiotic and biotic factors. The environmental resistance will be slow when a population is introduced to a new environment. Gradually the resistance increases reducing the population growth.

Chapman(1928) proposed the term biotic potential to designate maximum reproductive power. He defines biotic potential as "the inherent property of an organism to reproduce" to survive and to increase in numbers. It is a sort of algebraic sum of number of young produced at each reproduction, the number of reproductions in a given period of time, the sex ratio and their general ability to survive under given physical conditions".

### **Population regulation:**

Although the population of any species has the ability to increase in numbers, it cannot increase indefinitely. After reaching the maximum growth, it maintains itself at the equilibrium level. After reaching the equilibrium level, the population remains there or declines depending upon the environmental conditions. Thus the population growth is regulated by many factors. These factors are broadly classified into two types namely density independent factors and density dependent factors.

The density independent factors include space, shelter, weather, food etc. They cause drastic changes in the size of the population.

The density dependent factors are intrinsic and they include competition, predation, emigration, diseases etc. The density dependent factors stabilize the population at asymptote.

### **Human population explosion:**

The rapid and dramatic increase in the size of human population is generally referred as population explosion. The word 'population explosion' has a familiar symmetry of the atomic bomb explosion. When compared to atomic explosion, population explosion is more permanent in nature. It has large amount of vegetative activity and is capable of creative output. It is observed that human population is increasing at very fast rate. The growth rate is

2% and it is multiplying once in 35 years. The Indian population is more than 103 millions. It is said that 2 babies are born for every three seconds. The human population of the earth is more than 6 billion.

The increase in human population in poor countries and developing countries is more. Similarly the human population is increasing in slums and among poor people when compared to others.

The history has shown that the human population is increasing at a very fast rate with the increase in civilization and development of science and technology.

#### Effects of human population explosion:

1. It causes unrest, misery, destruction and competition among the human beings.
2. It leads to increased air and water pollution.
3. It leads to deforestation, shortage of natural resources and food materials.
4. It leads to increased starvation, malnutrition and infant mortality. It is estimated that about 500 million suffer from malnutrition and about 12000 people die of hunger each day. In India alone a million children die each year from malnutrition.
5. It leads to the increase in contagious diseases and wars.

Population size	year	Time required for increase by 1 billion
From 0 to 1 billion	1800	2.5 million years
From 1 to 2 billion	1930	130 years
From 2 to 3 billion	1960	30 years
From 3 to 4 billion	1975	15 years
From 4 to 5 billion	1987	12 years
From 5 to 6 billion	1998	11 years

#### 7. Community ecology:

The living organisms are interrelated and interact with one another. They also associate with one another. The successful survival of organisms depends on the intimacy of the associations. The associations may be between plants and plants, plants and animals. There are two types of animal associations namely

1. Intra specific relationship and
2. Interspecific relationship.

The relationship between the members of the same species is called intraspecific relationship. For example the relationship between children and parents.

The interspecific relationship can be broadly classified into 3 types namely

1. Neutral relationship
2. Positive relationship and
3. Negative relationship.

#### 1. Neutral relationship (0,0) (0=No effect):

It is also called neutralism. It is an interspecific relationship where no species is affected. For example Robin bird and squirrels living in the same tree and same forest.

#### 2. Positive relationship: (+, 0) *where one or both the species are benefited.*

In this interspecific relationship, one species is benefited but the other is not harmed. There are 3 types of positive interrelationship. They are

1. Mutualism



2. Protooperation and
3. commensalism.
1. Mutualism(+, +):

It is an interspecific relationship where both the species are benefited. The term mutualism means 'living together' and it was coined by De Bary. For example (1) sea anemone and hermit crab. The sea anemone is benefited by the free ride to the new feeding grounds. The hermit crab is benefited by getting protection by the nematocysts of sea anemone. (2) Rhizobium and leguminous plants. The Rhizobium bacteria gets shelter and carbohydrates from the plants. The leguminous plants are benefited in the form of nitrates as bacteria fix up atmospheric nitrogen. (3) Lichens: The fungus is benefited by algal cells as they produce carbohydrates by means of photosynthesis. The algal cells are benefited in having protection, moisture and minerals from the ~~algal~~ <sup>fungus</sup> cells.

2. Protooperation(+, +):

It is a primitive type of cooperation present between two different species, which is beneficial for both of them. However the relationship is not obligatory. For example (1) Crows and Buffaloes. The Buffaloes keep quiet when the crows sit on the body and pick the ticks present on the body.

(2) White herons and grazing animals: whenever grazing animals move in the grasslands, the white herons pick up the insects and also the ticks present on the body. In this relationship, the cattle get two benefits namely they get rid off external parasites and they are warned of the approaching enemies by the activity of the birds as 'watch men'.

(3) Crocodile and birds: Crocodile allows the crocodile birds to go deep into the mouth cavity so that they can remove the leeches found in between the teeth. Thus the crocodile get rid off the leeches and birds obtain food.

3. Commensalism(+, 0):

It is a symbiotic interspecific relationship where in one partner is benefited and the other is not harmed. The term commensalism means 'Eating at the same table'. For example (1) Sucker fish and Shark: The sucker fish Echeneis usually attaches itself to the body of shark. The sucker fish gets two benefits namely it gets transported by shark and it gets food by feeding on the left over of the food taken by the shark.

(2) Chaetopterus and crab: The crab polyonx lives in the posterior end of the tube of chaetopterus. The crab gets <sup>3</sup> benefits namely it gets protection from enemies, it gets food from the outgoing water and it gets oxygen from the water current.

### III NEGATIVE INTERSPECIFIC INTERRELATIONSHIP:

It is a kind of interspecific relationship where one or both species are harmed. It is of 4 kinds namely antibiosis, parasitism, predation and competition.

- i) Antibiosis (-, 0):

It is a kind of negative interspecific relationship where, one is harmed by the other. One species produces a secretion of harmful substances called antibiotics. Ex (1) fungi produces harmful substances like penicillin, streptomycin, aureomycin etc. (2) The blue green alga microcystis produce a toxic substance, called hydroxylamine. This chemical kills the freshwater fishes and the cattle that drinks this water.

2. Parasitism(+, -):

Parasitism is negative interspecific relationship where one partner is benefited at the expense of the other. The partner which is benefited is called parasite. The other partner is called host. The parasite can be

- a) Permanent parasite: Ex; Tape worm, *Nuchistella*, *Schistosoma*
- b) Temporary parasite: Ex: Glochidium larva of freshwater mussel. *Mosquito*, *beetle*
- c) Ectoparasite: Ex: Mosquito.
- d) Endoparasite: Ex: Liver fluke.
- e) Intercellular parasite: Ex: Ascaris.

- f) Intracellular parasite: Ex: Plasmodium vivax.
- g) Phytoparasite: Ex: Tobacco mosaic virus.
- h) Zooparasite: Ex: Mosquito.
- i) Facultative parasite: Ex: Soil nematodes.
- j) Obligatory parasite: Ex: Ascaris.
- k) Hyperparasite: Ex: Fungi present on the body of parasites.

**Exploitation:** One animal is exploited by the other. Parasitism and predation form good examples. Deer exploits the grass. Lion exploits the deer for food. Mosquito exploits man for blood.

3) **Predation (+, -):**

It is a negative intraspecific relationship where one species kills and devours the other species for food. The species, which kills the other is called predator. The species, which is killed, is called prey.

All animals and insectivorous plants are predators. The predators can be herbivores or carnivores. The predators have hunting ability. They select food on the basis of size. They hunt only when it is necessary for them to procure food.

The interaction between predator and helps in maintaining dynamic balance between the populations of predators and preys. For example deer and tiger, insects and frog, grass and cattle, frogs and snakes and eagle.

4) **Competition (-, -):**

Competition is a negative interaction between two different species or two different individuals of a same species for a particular resource. Therefore the competition can be intraspecific competition or interspecific competition. In this relationship both the individuals or species are harmed. However one individual or one species may be benefited in certain cases. Ex: 1. Competition between grazing animals like deer, cattle to get the grass. 2. The competition between different species for food or shelter like different birds. 3. Competition between paramecium aurelia and paramecium caudatum.

During competition one individual or one species may be harmed or exterminated. In the field of competition 'Gause principle' is followed. Gause principle states, "Two species with identical ecological niches can not occupy the same environment". It means that the two species when they occupy the same ecological niche, gradually one species becomes extinct at the cost of the other. For example when P. aurelia and P. caudatum are cultured together, P. Caudatum cannot face the competition and is exterminated.

Sl no	Type of relationship	Effects		General results
		Sp A	Sp B	
1.	Neutralism	0	0	Neither affects the other
2.	Commensalism	+	0	Favourable to A
3.	Mutualism <i>Proto Cooperation</i>	+	+	Favourable to both <i>not obligatory</i>
4.	Antibiosis	-	0	A is affected
5.	Parasitism	+	-	Favourable to A
6.	<i>Exploitation</i> Predation	+	-	Favourable to A
7.	Competition	-	-	Harmful to one or the other

Pollution

4. **Pollution: Definition, types, water, air pollution with reference to industrial, thermal, organic and inorganic pollutants.**

Pollution is an undesirable change in the physical, chemical and biological characteristic of air, land and water that affects the living organisms and upsets the ecological balance.

The substances that cause pollution are called pollutants. They are of two types namely non-degradable pollutants and biodegradable pollutants.

Non-degradable pollutants are the pollutants which don't degrade or decompose naturally and retain their harmful effect. Ex. Aluminum cans, mercurial salts, DDT plastics etc.

Biodegradable pollutants are the pollutants which undergo the natural process of decay and decomposition. They lose their harmful nature gradually. Ex. Domestic sewage, paper etc.

**Kinds of pollution:**

There are different kinds of pollution namely air pollution, water pollution, soil pollution, industrial pollution, thermal pollution, sound pollution, pesticide pollution, radioactive pollution, automobile pollution, sewage pollution etc.

**Air pollution:**

Air pollution is the undesirable change in the physical, chemical and biological characteristic of air which is harmful to living organisms and that affects the ecological balance.

The common air pollutants are CO, CO<sub>2</sub>, NO<sub>2</sub>, SO<sub>2</sub>, NH<sub>3</sub>, H<sub>2</sub>S, smoke, soot, dust, chlorine, ionizing radiations etc.

**Causes or sources of air pollution:**

The major causes of air pollution are as follows:

1. **Automobiles:** The combustion of petrol and diesel in automobiles like scooters, bikes, mopeds, buses, vans, cars etc., release harmful gases, dust and heat into the air.
2. **The transport vehicles:** The trains, aero planes, trucks and other transport vehicles also add to air pollution.
3. **Industries:** The cement industries, iron and steel industries, aluminum and graphite industries release huge amount of dust and smoke into air. The cotton ginning industries, asbestos factories release fibers into the environment. The petrochemical industries and other industries burn fossil fuels and release pollutants like SO<sub>2</sub>, NO<sub>2</sub>, CO, CO<sub>2</sub>, etc. The industrial accidents Bhopal gas tragedy have also caused air pollution.
4. **Power plants:** The thermal power plants burn huge amounts of coal to get steam. The burning of coal releases ash, SO<sub>2</sub>, CO<sub>2</sub>, dust etc. in addition many industries will have generators and power plants which supply electricity or steam. They also cause pollution.
5. **Field burning:** The burning of sugarcane fields, grass lands and forests releases CO, CO<sub>2</sub>, dust etc.
6. **Waste incinerations:** the useless and harmful solid wastes like waste paper, cotton from hospitals, covers and empty boxes of consumables and other disposable objects are burnt by the municipalities, clinics and corporations. The burning of these substances releases harmful gases, dust, smoke etc.
7. **Radioactive pollution:** The testing and explosion of atomic bombs releases ionizing radiations which include alpha particles, beta particles and gamma rays. The atomic bomb explosion on Hiroshima and Nagasaki in 1945 by USA caused air pollution.
8. **Wars and population explosion:** The use of explosives and chemical weapons in wars as in Gulf war, Vietnam war releases poisonous gases into air. The population explosion leads to air pollution by fuel combustion, smoking etc.

**Effects of air pollution:**

1. The CO combines with haemoglobin to form carboxyhaemoglobin, which in turn reduces the oxygen carrying capacity of blood in man. It also causes headache,

- dizziness, vomiting and fatigue. The CO combines with ozone to form CO<sub>2</sub> and oxygen and there by reduces the ozone umbrella
- ✓ 2. The presence of SO<sub>2</sub> in air causes irritation to the eyes and respiratory tract. The higher concentrations of SO<sub>2</sub> cause respiratory problems like bronchitis, emphysema, lung cancer etc., in man.
  - ✓ 3. SO<sub>2</sub> damages vegetable crops affects plant growth and nutrient quality of plant products. Higher levels of SO<sub>2</sub> causes death of leaf tissues called leaf necrosis. It also causes bleaching of leaf pigments called chlorosis.
  - ✓ 4. SO<sub>2</sub> causes paper to become brittle and fragile, leather to loose strength and to disintegrate, causes erosion of building materials like marble, mortar etc. SO<sub>2</sub> released from Mathura oil refineries and other industries are accelerating the deterioration of world famous Taz mahal in Agra.
  - ✓ 5. SO<sub>2</sub> combines with moisture to form H<sub>2</sub>SO<sub>4</sub>. this results in acid rain which reduces fertility of soil, burning of forests and defoliation of trees.
  6. H<sub>2</sub>S causes headache, nausea, collapse, coma and finally death at the concentration of 1-3 ppm.
  7. Hydrocarbons at high concentration have carcinogenic effects on lungs. They also cause swelling of lungs.
  8. The hydrocarbons, nitrogen oxides, photochemical oxidants combine with dust in presence of sunlight to form photochemical smog or smog. Smog is formed of fog and smoke.
  9. NO<sub>2</sub> causes nose and eye irritation and pulmonary discomfort. The nitrogen oxides also cause severe chronic diseases of heart, lungs and eyes.
  - ✓ 10. Lead is released into air from automobile exhaust. It affects on children's brain, interferes with the development and maturation of RBC'S.
  - ✓ 11. Particulate pollutants like pollens causes asthma and other respiratory problems.
  12. The inhalation of dust containing free silica, silicon oxide causes a disease of lungs called Silicosis.
  13. Small fibers of asbestos irritate lung and causes a disease called Asbestosis.
  14. Black lung disease is common in coal mine workers, while white lung disease occurs frequently in textile workers.
  - ✓ 15. Traces of mercury cause nerve damage and death.
  - ✓ 16. The increase of CO<sub>2</sub> in the atmosphere causes global warming.

#### Controlling measures or preventive measures:

The air pollution can be controlled by the following methods:

- ✓ 1. The conditions of the roads and public transport system have to be improved. This will reduce the use of two wheelers and cars.
- ✓ 2. The increase in the services of railway also reduces the use of buses and trucks for the transport.
- ✓ 3. The widening of roads, one way traffic, and separate track for bicycles, cars and good road planning reduces traffic jams and there by reduces air pollution.
- ✓ 4. the use of filters, scrubbers, cyclone collectors and electrostatic dust precipitators in factories like cement factories reduces air pollution.
- ✓ 5. The development and use of energy efficient engines in automobiles reduces air pollution.
- ✓ 6. The emission of CO, hydrocarbons and nitrogen oxides can be controlled by proper cleaning and tuning of carburetor and silencers and by appropriate changes in devices for improving combustion.
- ✓ 7. The development and use of non conventional energy resources like wind energy, solar energy, biodiesel etc reduces air pollution.

8. Greenery and reforestation helps in reducing the concentration of CO<sub>2</sub> in the atmosphere.

### Water pollution:

The undesirable change in the physical, chemical or biological characteristic of water that affects human beings and aquatic organisms is called water pollution.

The water pollutants include domestic sewage, oxygen depleting wastes, infectious agents, plant nutrients, insecticides, herbicides, lead, mercury, detergents, and radio active substances, heat from power plants etc.

### Sources or causes of water pollution:

1. **Sewage and domestic wastes:** The sewage is commonly a cloudy dilute aqueous solution containing mineral and organic matter. It includes human excreta, soap, detergent, metals, glass, garden wastes etc. the drainage wastes from towns and cities reach and contaminate the rivers, lakes and shallow regions of marine water.
2. **Industrial effluents:** The industrial effluents are discharged into rivers and seas. They contain toxic chemicals, phenols, aldehydes, ketones, cyanides, metallic acids, oils, greases, dyes, radioactive wastes, thermal pollutants.
3. **Agricultural discharges:** The agricultural discharges that reach water from agricultural practice include fertilizers, pesticides, herbicides, farm wastes, manure slurry, pollutant and animal's debris, soil erosion, silt etc.

### Effects of water pollution:

1. Sewage water pollution leads to the spread of epidemic diseases like cholera, typhoid, bacillary dysentery and jaundice. Nearly 80% of epidemic diseases of human beings are mainly due to water pollution.
2. Sewage will be containing the eggs and larvae of many worms which are parasitic to man. Hence the contamination leads to spread of these parasites.
3. Sewage contains organic matter and it leads to the increase in the population of decomposers. There will be increase of biological oxygen demand (BOD). BOD is the amount of oxygen required by the microorganisms to decompose the existing organic matter present in water. The increase in BOD affects and sometimes kills the aquatic biota because of oxygen deficiency.
4. The presence of disinfectants in water causes mortality of fish, planktons and diatoms.
5. The presence of mercury in industrial effluents causes crippling and fatal diseases like Minamata of Japan.
6. The presence of asbestos, lead, cyanide etc in water cause cellular degeneration in brain which results in rigidity, com and numbness.
7. The heat released by industrial effluents kills the aquatic organisms and severely alters the aquatic ecosystem.
8. The excess use of fertilizers has lead to the increase of nitrate in water. Nitrites cause a disease in children called "methemoglobinaemia" (blue baby condition). Nitrates interfere with oxygen carrying capacity of blood.
9. The presence of nitrates and phosphates in water leads to enormous growth of phytoplankton and zooplankton and causes "eutrophication" in water. It leads to depletion of oxygen and increase of BOD causing the death of fish and aquatic life.
10. The presence of manganese in water bodies causes neurological disorders and death in man.
11. Siltation is a serious and damaging pollutant in streams and rivers. This creates high turbidities in water, hinders the free movement of aquatic organisms, growth of fishes and their productivity.
12. The presence of Non-degradable pollutants like DDT in water causes the death of aquatic biota. The DDT passes through the food chain and undergoes "biological

- magnification" because it has affinity to get accumulated in the fatty tissue. When such fishes containing DDT are eaten, it leads to cancer in man.
13. the presence of radio-nucleides in water causes skin cancer, breast cancer, DNA breakage etc in man.

Controlling measures: The intensity of water pollution can be controlled or minimized by the following methods:

1. The reduction of waste at source, harvesting and removal of biomass, trapping of nutrients, fish management and aeration helps in stabilization of aquatic ecosystems.
2. The industrial effluents can be reduced by reutilization and recycling of wastes by giving proper treatment.
3. The sewage pollution can be reduced by the use of sewage treatment plant. It has three phases. In the first phase floating and suspended solid objects are removed. In the second phase aeration is done to provide oxygen needed for the decomposition of organic matter by the microorganisms. The fine and colloidal particles are allowed to settle to the bottom. Later the water is chlorinated to kill the microorganisms, including the pathogens. In the third phase harmful chemicals are removed by the chemical process.
4. The waste water can be used for fish farming and for industries.
5. The water pollutants can be removed by techniques like absorption, electro-dialysis, ion-exchange, reverse osmosis etc.
6. The effective implementation of water pollution Act and proper functioning of pollution control boards helps in reducing water pollution.
7. Preventing the excessive use of fertilizers, herbicides, weedicides, pesticides and encouraging the organic farming and natural farming helps in reducing water pollution.

9. Radiations and chemical hazards: Thermal power projects, measures of disposal, ozone layer, green house effect, global warming

Contamination of environment with radioactive elements is called radioactive pollution.

Certain elements emit ionizing radiations. These elements are called radioactive isotopes.

Ionizing radiations are high energy radiations. They are able to remove electrons from atoms and attach them to other atoms, thereby creating positive and negative ion pairs.

Radiations refer to the rays of light or heat. There are two sources namely natural radiations and manmade radiations.

Natural radiations include cosmic rays, environmental radiations and internal radiations manmade radiations include X-rays, radioactive fall out and other miscellaneous sources like TV sets, wall clocks etc.

Radiations are of two types namely electromagnetic radiations and particulate radiations.

Electromagnetic radiations include radio waves, infrared waves, visible light and ultraviolet light.

Harmful effects of radiations :

1. Ultraviolet light passes through the horny layer of the skin and injure the cells of germinative layer of the epidermis.
2. UVL injures the surface cells of cornea, making the latter opaque. This causes snow blindness, which is nothing but blindness for few days. prolonged exposure may result in permanent blindness.
3. Prolonged exposure of X-rays destroys the germinative layer of epidermis, producing severe burns. X-rays affect growing tissues, blood forming tissues and developing gametes
4. Alpha particles if inhaled with air or ingested with food or water prove harmful to the tissues.
5. Beta particles cause internal damage to a person's body if inhaled or swallowed.

6. Neutrons are highly dangerous because they cause atoms to become radioactive. They penetrate deep tissues and cause damage.
7. Nuclear bomb explosions like that of Hiroshima and Nagasaki bomb explosions and accidents at nuclear power stations like Three Mile Island and Chernobyl have caused leukemia, peripura disease, still births, deformed babies etc.
8. Radiations block mitosis and cause genetic effects.

### 3/1 Thermal power projects:

Thermal power projects use coal as source of energy. The burning of coal produces huge amount of fly ash, nitrogen oxides, sulphur oxides etc. The disposal of fly ash is a serious environmental problem.

In recent days the fly ash is used to manufacture light weight bricks, fire proof materials, and even to convert it into fertilizers.

### 3/1 Ozone layer depletion.

Concept : Ozone layer is present in the stratosphere between 20 and 26 km above the sea level. This layer of ozone is called ozone umbrella or ozone shield because it protects the living organisms from harmful effects of strong UV radiation. The absorption of UV radiation increases with the thickness of ozone layer. The concentration of  $O_3$  in the stratosphere changes with the seasons. It is highest in February-April (spring season) and lowest during the period July-October (fall season).

Ozone is the variant of oxygen. UV-radiation from the sun causes photo-dissociation of ozone into  $O_2$  and O. But  $O_2$  and O quickly recombine to form  $O_3$ . This dissipates the energy of UV as heat. An equilibrium is established between generation and destruction of  $O_3$  leading to steady state concentration of ozone layer. The thickness of ozone layer if condensed averages 0.29 cm above the equator and may exceed 0.40 cm above the poles at the end of winter season.

The decline in the springtime ozone layer thickness is called ozone hole. It was first discovered in 1985 over Antarctica.

#### Causes

1. CFC's used in air conditioners, aerosols and refrigeration's escape into the atmosphere and destroy ozone layer. CFC's produce "active chlorine" (Cl and ClO radicals) in presence of UV radiation. These radicals convert ozone into oxygen.
2.  $CH_4$  also causes ozone destruction.
3.  $N_2O$  also causes ozone layer depletion. Sherwood Rowland, Mario Molina and Paul Crutzen were awarded Nobel Prize in 1995 for their discoveries related to ozone depletion.

#### Effects

1. The increase in ozone holes or the thinning in ozone thickness increases UV-B radiation reaching the earth's surface. A five percent loss of ozone results in ten percent increase in

UV-B radiation. This radiation causes many harmful effects on humans and other living organisms.

2. In humans it leads to the increase in skin cancer and incidence of cataract.
3. It also reduces the functioning of immune system.
4. It inhibits photosynthesis in most phytoplankton.
5. It damages the nucleic acids and causes genetic variations.

#### Controlling measures

1. To limit the production and use of ozone depleting substances like CFC's, methane and nitrogen oxides.
2. Phasing out of ozone depleting substances in stages. (In 1987, 27 industrialized countries signed the an international agreement called Montreal Protocol to protect ozone layer by taking a number of steps to stop ozone depletion. Now more than 175 countries have signed this protocol.)
3. To develop and use alternatives to CFC's.

#### Global warming and green house effect

The increase in the global mean temperature due to the increase in the concentration of green house gases like  $\text{CO}_2$ ,  $\text{CH}_4$  and other green house gases is called global warming.

There is increase in the concentration of  $\text{CO}_2$  due to industrialization, automobiles, combustion of fossil fuels etc. Similarly there is increase of concentrations of gases like methane ( $\text{CH}_4$ ), nitrous oxide ( $\text{N}_2\text{O}$ ) and chlorofluorocarbons (CFCs) in the lower atmosphere. These gases are called radiatively active gases or green house gases because they can absorb long wave infrared radiation. The increased amounts of green house gases are affecting global climate and this is now called global change.

#### Concept

The green house gases present in the atmosphere acts like a window glass pane. Most of the solar radiation enters up to the earth's surface. But the green house gases do not allow a substantial amount of long wave (infra red) radiation emitted by the earth to escape in space. It is absorbed by the green house gases. The atmosphere radiates back part of this energy back to the earth. This downward flux of radiation is called green house flux. And it keeps the earth warm. Thus the green house gases act like a glass pane in the green houses where plants are grown.

The green houses acting like a glass pane over the earth controlling the escape of heat from the earth's surface to the outer space so as to keep it warm is known as green house effect.

The mean annual temperature of the earth is about  $15^\circ\text{C}$ . If the green house gases are absent the temperature falls to about  $-20^\circ\text{C}$ . The increase in the concentration of green house gases results in retaining more and more infrared radiation. This leads to increase in mean temperature of the earth and this is called global warming.

#### Causes

1.  $\text{CO}_2$  is the most important green house gas. Its concentration has increased from the pre-industrial level of 280 ppm to about 368 ppm in 2000. It is largely due to fossil fuel burning, deforestation and change in land use.  $\text{CO}_2$  contributes to 60% of global warming.



2.  $\text{CH}_4$  concentration in atmosphere has more than doubled (1750 ppb) than its concentration during pre-industrial times. The major sources of methane include freshwater wetlands, enteric fermentation of cattle and flooded rice fields.  $\text{CH}_4$  contributes 20% to global warming.
3. CFC's are used in air conditioners, aerosols, and refrigeration units. They are leaking to atmosphere and their concentration has increased. CFC's contribute 14% to global warming.
4. The concentration of  $\text{N}_2\text{O}$  in the atmosphere is increased from about 270 ppb (parts per billion) in pre-industrial times to 316 ppb in recent times.  $\text{N}_2\text{O}$  contributes 14% to global warming.

#### Effects

1.  $\text{CO}_2$  fertilization effect on plants: The growth of many plants particularly  $\text{C}_3$  species, could increase by 30% on average.
2. Effect on weather and climate: The average temperature of the earth may increase by 1.4 to 5.8°C by the year 2100 from to 1990 level. This increases the frequency of extreme events like floods, droughts etc. The sea level may rise up to 0.88 m over the 1990 level. Several low-lying islands may be submerged. Coastal cities and areas maybe submerged. It will affect on human settlements, tourism, freshwater supplies, fisheries, agricultural and dry lands
3. Global warming leads to change in altitudinal and latitudinal distribution pattern of organisms. A rapid rise in temperature may leads to large-scale death of trees and their replacement by scrub vegetation.
4. Increased temperature increases plant diseases and pests. Thus it may lead to decrease in crop production.

#### Control measures

1. Reducing the emission of green house gases by limiting the use of fossil fuels and by the use of alternative renewable sources of energy like wind, geothermal or solar energy.
2. By increasing the vegetation cover particularly by afforestation, for photosynthetic utilization of  $\text{CO}_2$ .
3. By limiting the use of CFC's and by developing substitutes for CFC's. (An international agreement to reduce green house gases was drafted in 1997 December held in Kyoto, Japan. This agreement is called Kyoto protocol. It requires countries to take appropriate measures to reduce their overall green house gas emissions to a level at least by 5 percent below the 1990 level by the commitment period 2008-2012.)
4. To limit the use of nitrogen fertilizers in agriculture for reducing  $\text{N}_2\text{O}$  emissions.

#### Acid rain

Concept: Acid rain is one of the main effects of air pollution. There is gradual increase in the concentration of  $\text{CO}_2$ ,  $\text{NO}_2$ ,  $\text{SO}_2$  gases in the atmosphere. These gases combine with the moisture to form acids. These acids reach earth by rain, fog and snow.

The different ways in which acids from atmosphere are deposited on the earth is known as acid rain. The acid deposition can be by wet deposition or dry deposition. The acidic water reaching earth through rain, fog and snow is called wet deposition. The acidic gases and particles reaching the earth by wind blown is called dry deposition. The dry deposited gases and particles can be washed from the trees and other surfaces by rainfall. The pH of acid rain is less than 5.6 and could be as low as 4 or below.

#### Causes

1. Sulphur dioxides are produced during combustion of fossil fuels like coal, petrol etc. They dissolve quickly in water to sulphuric acid.
2. Nitrogen oxides are produced during combustion of fossil fuels like coal, petrol etc. Lightning in the sky naturally produces nitrogen oxides. They rapidly oxidize to form nitric acid.
3. Carbon dioxide is formed by organisms during respiration and by industries and automobiles during the combustion of fossil fuels. It combines in air with water to form weak carbonic acid.

#### Effects

1. It causes defoliation in trees and reduces the rate of photosynthesis.
2. It acidifies freshwater resources and causes the death of aquatic organisms like plankton, mollusks and fishes.
3. It damages building materials. Our heritage monuments like Taj Mahal at Agra are in danger.
4. It causes burning of skin in animals and fabrics of human beings.
5. It also kills the soil microorganisms leading to loss of fertility and biodiversity.

#### Controlling measures

1. To reduce or prevent the combustion of fossil fuels.
2. To use alternative energy resources like solar, wind, and geothermal and tidal energy sources.
3. To take up extensive increase in vegetation cover like afforestation.
4. To use catalytic converter filters in vehicles, which convert nitrogen oxides to nitrogen.

9. **Wild life conservation and management:** Red data book, Endangered species, Major wild life sanctuaries, national parks of India. Major organizations involved in wild life conservation, Chipko and Appiko movements

#### Wild life conservation and management

**The uncultivated species of plants and undomesticated species of animals together constitute wild life.**

India is rich in wild life. It has 390 species of mammals, about 1232 species of birds, 456 species of reptiles, 228 species of amphibians, 2546 species of fish, 450 reptiles, 5000 molluscs and 60,000 insects. It has ferns (Petridophyta) with 900 recorded species and more than 1080 orchids.

The human and natural activities have lead to the depletion of wild life. Over the past 2000 years about 106 species of animals and about 140 species of birds have extinct in the world. About 600 species of animals and birds have become endangered species. The species whose number is less and is having the threat of becoming extinct is called endangered species. Many species of bamboo, sandal wood and orchids have also become endangered species.

It is estimated that, after Independence, the country has lost 4.696 million hectares of forestland to non-forestry purposes (MOEF 1996).

The important reasons for depletion of wild life are as follows:

1. Deforestation due to agriculture, roads, railways, mining etc.
2. The extensive hunting of animals for skin, horns, tusks etc.
3. Poaching (illegal killing) of wild animals for flesh, skin, horns, tusks etc.
4. Establishment of hydro-electric projects and dams.
5. Pollution of rivers.
6. Poor breeding potential of some wild animals like tigers.
7. Natural calamities such as floods, fires, droughts, epidemics etc.

Wild life is a renewable resource. Therefore there is a great need to conserve wild life. The important reasons for wild life management are as follows:

1. Wild life helps in maintaining the balance of nature. The structural and functional relationship and interdependence in nature can be maintained by having wild life.
2. The wild life forms a rich source of genes, which may be needed to produce disease resistant, drought resistant, high yielding plant varieties and also medicines.
3. The wild life preservation is useful in understanding the morphology, physiology, behaviour and life cycle of wild animals.
4. The wild life preservation is the best means of sports and recreation to man.
5. It is a source of income. The sustainable production of skin, hides, horns, fur, ivory and stuffed specimens for the museums form a source of money.
6. The wild life forms a cultural asset and can promote eco-tourism.

The wild life management includes in situ and ex situ methods. In situ methods include setting of national parks, sanctuaries, bio-reserves and habitat preservation. The ex situ methods includes setting of botanical gardens, zoological gardens, zoos, seed banks, gene banks etc.

#### (i) Setting up of national parks, sanctuaries, bio-reserves

The methods to conserve and protect wild life are called methods of wild life management. The important methods are as follows:

1. The wild life protection Act 1972 along with the amendments is in force in India. Under the Act, possession, trapping, shooting of wild animals alive or dead, serving their meat, transport and export are controlled and watched by chief wild life warden.
2. The hunting of females and young ones has been completely prohibited under this Act.
3. The hunting is restricted and license is needed for hunters. The hunting of endangered species is banned.
4. Strict vigilance should be there to reduce poaching. The illegal exploitation of a wild species is called poaching. The offenders should be severely punished.
5. The habitats of the wild life should be improved by raising plantations of better fodder grasses and trees, by constructing water holes and salt licks.
6. The setting up of wild life projects and its scientific management helps in conservation. The project tiger was launched in 1973 and is a successful story. It was initiated by government of India to protect and maintain a viable population of tigers. 18 tiger reserves have been established in 13 states. Bandipur tiger reserve is present in Karnataka. The project elephant is also launched to save elephants.

7. The setting up of national parks and sanctuaries form an important method of conserving wild life. India has set up more than 400 wild life sanctuaries and 70 national parks.
8. National parks are the reserves, which are large and diverse enough to whole sets of ecosystems. They preserve flora, fauna, landscapes and historic objects of an area. Ex. Corbett national park, Hazaribagh national park, Simlipal national park.
9. Sanctuaries are the places where the killing or capturing of animals is prohibited except under orders of an authorized person. They provide protection and optimum living conditions to wild animals. Ex. Kaziranga wild life sanctuary, Ranganathittu bird sanctuary, Bandipur wild life sanctuary.
10. Setting up of zoos also helps in conserving wild life. The rearing of wild animals in small enclosures or isolated land masses surrounded by fences or trenches do provide good environment. They do reproduce in such habitats. Many zoos are known for reproduction of wild animals. Ex. Mysore zoo, Hyderabad zoo.
11. The environmental awareness education to the people living in the surrounding villages of national parks and sanctuaries helps in conserving the wild animals.

### (ii) Habitat Preservation

The natural habitats of animals and plants have to be preserved from the clutches of modern man. The habitats can be either microhabitats or macrohabitats. Their preservation is essential for the survival and propagation of the species.

The important methods of habitat preservation are as follows:

1. **Restoration of habitats:** The natural conditions of the habitat have to be restored. The denuded forests have to be restored by afforestation. The polluted rivers should be brought back to the original condition by treating the effluents or by avoiding the effluents.
2. **Improvement of habitats:** The conditions of the habitats can be improved by providing water holes and salt licks. The fodder grasses can be introduced to provide food to the herbivores.
3. **Providing shelter and cover:** The development and construction of shelters and covers helps in the survival of wild animals like deers, lions etc.
4. **Artificial stocking:** Certain species of animals and plants can be introduced to improve the interrelations of the food chains and trophic levels.
5. **Game farming:** The crucial stages in the life cycle of endangered species have to be protected from man and other predators. The eggs of crocodiles and turtles can be collected and hatched in the laboratories. Later the young ones can be released into the natural habitats.
6. **Epidemic control:** The epidemic diseases of wild animals have to be controlled with the help of veterinary experts.

Protected areas:

Protected area is a broad term given primarily to National Parks and Sanctuaries meant for affording protection of wild animals and their habitats. They also include Game Reserves and Biosphere Reserves. The Indian Board for Wildlife which is being headed by the Prime Minister of India has recommended the establishment of a net work of Protected Areas such as National Parks, Sanctuaries and Biosphere Reserves to cover representative samples of major Wildlife Eco System with Geographical distribution.

Q4. **The Red data Book:** IUCN publishes a list of animals and plants which are in the verge of extinction in a book called red data book. It is also prepared by the Zoological Survey of India for the fauna of Indian region. In 1994 ZSI has listed 57 mammals of India as threatened, 16 as insufficiently known and 2 as species extinct. The Red list of the threatened animals of the IUCN, prepared in 1996 contains 75 species of mammals, 73 species of birds, and 16 species of reptiles, 12 species of Primate and a large number of insects. IUCN publishes red data book every year.

**Endangered species:** The species which are in the verge of extinction are called endangered species. Ex. Elephant, Tiger, Lion, Crocodile, Python.

**Major wild life sanctuaries, national parks of India**

Wild life sanctuary/National park	State	Important wild life
✓ 1. Kaziranga wildlife sanctuary	Assam	Rhinoceros, Bison, Elephants
2. Manas wildlife sanctuary	Assam	Rhinoceros, Tiger, Wild buffalo, Sambar
3. Palamau national park	Bihar	Tiger, Chital
4. Hazaribaugh national park	Bihar	Leopard, Sambar, Cheetal
5. Bhagavan Mahadev Wild life sanctuary	Goa	Bison, Sambar, Cheetal
✓ 6. Gir forests	Gujrath	Lion, Elephant, Leopard
✓ 7. Bannerghatta National Park	Karnataka	Elephant, Tiger, Crocodile, Cheetal, Barking deer
8. Bandipur wild life sanctuary (Nagarhole)	Karnataka	Elephant, Tiger, Sambar, Gaur, Jackal, Wild Boar, Four horned antelope
9. Rajeev Gandhi National Park squirrel,	Karnataka	Tiger, sloth bear, Sambar, Flying Barking deer
10. Ranganathittu Bird Sanctuary	Karnataka	White ibis, Darter, Cormorant, Open bill stork, Pond heron
11. Dandeli Santuary, North Canara	Karnataka	Elephant, Gaur, Wild boar, Sloth bear
12. Periyar sanctary	Kerala	Elephant, Bison, sambar, Gray horn bill
13. Nagarjunsagar sanctuary	Andhra Pradesh	Tiger, Panther, Nilgai
14. Papikonda sanctuary	Andhra Pradesh	Tiger, Panther, Nilgai, Hyena, Four horned antelope

15	Kanha national park	Madhya Pradesh	Tiger, Panther, Gaur Black buck, Cheetal
✓ 16	Chilka lake	Orissa	Flamingos, Cranes, Ducks, Water fowls
17	Simpilpal national park	Orissa	Tiger, Leopard
18	Dachingaum sanctuary	Kashmir	Himalayan brown and black bear, Snow leopard, Hangul deer
19	Desu sanctuary	Kashmir	Black bear, musk deer
20	Bharathpur bird sanctuary	Rajasthan	Siberian crane, Crane, Cormorants, Painted stork, Heron
21	Sariska sanctuary	Rajasthan	Tiger, Panther, Leopard
✓ 22	Annamalai wild life sanctuary	Tamil Nadu	Elephant, Panther, Gaur, Cheetal, Deer
23	Madhumalai wild life sanctuary	Tamil Nadu	Elephant, Panther, Gaur, Cheetal, Deer
24	Vedathangal sanctuary	Tamil Nadu	Spoon bill, Pelican
✓ 25	Jim Corbett national park	Uttar Pradesh	Elephant, Tiger, Panther, Cheetal, Sambar, Crocodile
26	Kedarnath wild life sanctuary	Uttar Pradesh	Himalayan brown and black bear, Musk deer, Snow leopard
✓ 27	Sunderban wild life sanctuary	West Bengal	Tiger, Deer, Python, Crocodile, Wild boar

### National Parks and Sanctuaries of Karnataka

Name of the National Park	Situated Place
1. Anasi National Park	Uttara Kannada
✓ 2. Bandipura National Park	Chamaraja Nagar
✓ 3. Bannerughatta National Park	Bangalore.
✓ 4. Kuduremukha National Park	Udupi & Chickmagalore
5. Rajivgandhi National Park	Coorg and Mysore
6. Arbithittu Sanctuary	Mysore
7. Adichunchanagiri Peacock Sanctuary	Mandya
8. Attiveri Bird Sanctuary	Uttara Kannada, Dharawad
9. Bhadra Sanctuary	Chickmagalur, Shimoga
✓ 10. Biligiri Rangana Betta Sanctuary	Chamaraja Nagar
11. Brahmagiri Sanctuary	Kodagu
✓ 12. Dandeli Sanctuary	Uttara Kannada
13. Daroji Bear Sanctuary	Bellary
✓ 14. Gudavi bird Sanctuary	Shimoga

15. Ghataprabha Bird Sanctuary	Belgaum
16. Kokkarebellur Bird Sanctuary	Mandya
17. Kaveri Sanctuary	Mysore, Mandya, Bangalore
18. Melkote Fox Sanctuary	Mandya
19. Mookambika Sanctuary	Udupi
20. Nugu Sanctuary	Mysore
21. Pushpagiri	Kodagu
22. Ranibennur Blackbuck Sanctuary	Haveri
23. Ranganathittu Bird Sanctuary	Mandya
24. Someshwara Sanctuary	Udupi
25. Sharavathi Sanctuary	Shimoga
26. Shettihalli Sanctuary	Shimoga
27. Tala Kaveri Sanctuary	Kodagu

**Major organizations involved in wild life conservation, Chipko and Appiko movements**

A number of organizations are involved in wild life conservation both at the international and national level. National geographic society, 'Friends of the Earth', 'Green Peace', 'Club of Rome' are well known organizations which are working at the international level.

At the national level Chipko and Appiko movements are popular.

**Chipko movement:**

It is known all over the world for its non-violent resistance to the destruction of forests. The word chipko is from Hindi and it means to embrace or hug the tree. The movement has its roots in India's cultural history. In 1730, the Maharaja of Jodhpur in northern India ordered the trees to be cut down. A Bhisnoi woman, Amrita Devi from Khajauri, a village 25 km from Jhodpur (Rajasthan) along with 36 other Bishnois protested against cutting down of trees. They braved themselves by hugging the trees before the tree cutter's axe. In 1973, some women in Himalayan region started modern chipko movement to protect the trees. People tried to protect the trees by embracing them. There is a village called Mandal in Chamoli district of Uttar Pradesh. This village is present amidst forest. The government had banned the cutting of trees for fuel wood and other purposes. However it had given license for a Allahabad contractor to cut trees for manufacturing toys. People opposed the cutting of trees. When contractor continued to cut trees the people embraced the trees. The women took the lead in this movement. The contractor stopped but after several weeks he started cutting trees at Rampur which was 30 kms away from Mandal village. The people of Mandal went there also by singing songs and educated the people of Rampur. All of them finally opposed the cutting of trees by embracing them. The contractor had to stop the cutting of trees.

In 1974 women lead the chipko movement at Joshi matt of Himalaya. At Reni village also women opposed the cutting of trees. Goura Devi took the leadership at Reni. Today the chipko movement has become very popular movement. People have understood the importance of trees. They have realized that trees help in conserving soil, recharging the underground water and in providing basic necessities of livelihood. Freedom fighter Sunder lal Bahuguna has been trying to popularize this movement. Chandiprasad Bhat is organizing the grass root workers.

**Appiko movement:**

Appiko movement has become very popular movement to save the forests in Karnataka. It got inspiration from Chipko movement. It started in 1983 in and around the villages of Sirsi and Siddapura of Karwar district of Karnataka. Panduranga Hegde was the leader. The people of

these places opposed the cutting of forest trees by embracing them. They took a procession and educated the people. They are keeping watch on the forests. They consider the forests as their God.

**Questions carrying 3 marks**

1. What are endangered species? Give examples.
2. Write a note on Habitat.
3. Mention any three wildlife sanctuaries of Karnataka.
4. Write a note on Red data book.
5. What are pollutants? Mention any three water pollutants.
6. Mention any three measures of preventing or reducing air pollution.
7. Write a note on Appiko movement.
8. Write a note on Green house gases.
9. Write a note on thermal stratification.
10. Write a note on cyclomorphosis.
11. Write a note on Population explosion.
12. Write notes on population density.
13. Write a note autecology.
14. What is synecology?

**Questions carrying 5 marks**

1. Write a note on Niche.
2. Write on Acid rain.
3. Briefly global warming.
4. Write a note on ozone depletion.
5. Write a note on Chipko movement.
6. Mention the effects of water pollution.
7. What are the controlling methods of air pollution?
8. Write a note on radio-active pollution.
9. Write notes on natality and mortality.
10. Write notes on biotic potential.
11. Write notes on population growth.
12. Write notes on population regulation.
13. What is mutualism? Give examples.
14. Write notes on parasitism.

**Questions carrying 10 marks**

1. Enumerate the ecological effects of light on organisms.
2. Enumerate the ecological effects of temperature on organisms.
3. Briefly explain the Limiting factors.
4. Give an account of energy flow in an ecosystem.
5. What is pollution? Describe the causes, effects and preventive measures of water pollution.
6. Give an account of wildlife management.
7. Give an account of interspecific relationships.
8. Explain habitat and ecological niche.



# III BSc (ZOOLOGY), Paper – VIII

## Ethology (Behaviour biology)

(VI Sem) 12-2013

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### Introduction

Ethology is a major branch of biology, which deals with the behavior of animals. The term ethology is made up of two Greek words: *ethos* means habit and *logos* means study. Ethology is of applied value in understanding sociology, physiology, psychology, criminology, anthropology and management of human resources.

Various workers have defined behaviour differently.

- Behaviour can be defined as 'the way an organism responds to stimuli in its environment. It is a directional activity necessary for survival.
- Behaviour is the response of living matter to some form of stimulus.
- Behaviour includes all those processes by which an animal senses the external world and adapts itself to that world.

Many ethologists have contributed to the development of this science.

**Historical perception :** Aristotle (340-322 BC) was a keen observer of animal behaviour. In his book *Historia Animalium*, he has mentioned information on pet animals and concluded that animals also possessed insight and love for families and their masters.

**Charles Darwin** laid the foundation of modern ethology in 1850. In 1871, Darwin published a book on behaviour called *the descent of man and selection in terms of sex*. He also made studies of the body postures of pet animals as a means of communication. Darwin's friend disciple **George Romanes** continued the study of animal behaviour. He published books like *Animal intelligence* (1882) and *Mental evolution of animals* (1884).

**Karl von Frisch** (1886-1983) from Germany is famous for his work on the communication in bees. **Niko Tinbergen** (1907-1988) from Holland and **Lorenz** (1903-1989) from Vienna are the founders of modern ethology. They got Nobel Prize in 1973 for their contributions to behavioural science. Lorenz stressed on the importance of direct observations under natural conditions. Tinbergen examined the functional significance of behaviour. **Ivan Pavlov** is famous for his experiment on conditioned reflex.

**Aims and objectives of ethology:**

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1. It helps in understanding the evolution of nervous system, sense organs and co-ordination.
2. Ethology aims at understanding animal behaviour like feeding, mating, fighting, nesting, territoriality etc.
3. It helps in understanding the concept of motivation, parental care and aggression etc.
4. It aims at understanding the physiological basis of behaviour.
5. It help in easy diagnosis of diseases in animals.
6. It helps the animal keepers to take proper care and to get maximum benefit from them.
7. It aims at understanding the behaviour of animals like instincts, reflexes etc.
8. Ethology aims at learning and understanding the behaviour of monkeys, termites etc.

#### Branches of Ethology:

Ethology has a number of branches :

**Ecology :** It deals with relationship between behaviour of a species and its environment.

**Ethogenetics :** It deals with the genetic basis of behaviour.

**Neuroecology :** It deals with the study nervous system that initiates and controls a particular behaviour.

**Ethoendocrinology :** It deals with the relations between hormones and behaviour.

**Human ethology :** It deals with the study of human behaviour.

#### Classification of Ethology:

Generally the behaviour is of two types : **innate behaviour** and **acquired behaviour**.(Learning). Innate behaviour is genetically controlled behaviour. Learning is believed to be largely dependent on experience.

The common **Innate behaviour** are Irritability, Tropism Taxis, Kinesis, reflexes. Instincts.

**Learning** behavoiur are Habituation, Imprinting, Trial and error learning and Reasoning.

#### Innate behaviour : (stereotyped behavior)

The innate behaviour is a kind of behaviour, which is essentially the outcome of inherited properties of nervous system. Innate behaviour is inborn and also called acquired, inherited, inherent, stereotyped. It is determined by heredity or genes. The innate behavior is stereotyped behavior. Stereotyped behaviours are stimulus bound behaviours. The innate behaviour helps in understanding the surrounding environment and also in survival.

The stereotyped behaviour includes *taxis, kinesis, Reflexes and instincts.*

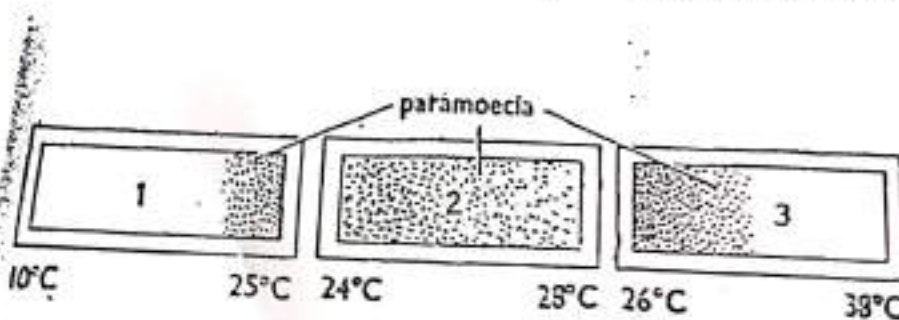
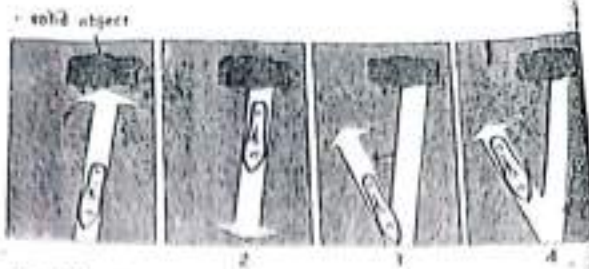


Fig. 14.1. Reaction of *Paramecium* to temperatures. Of various temperatures the paramecia avoid extremes of cold and heat.



Taxis :

Fig. 7.14 Amoeba showing a negative or avoiding reaction to solid obstacle. The white arrow indicates the direction of the path.

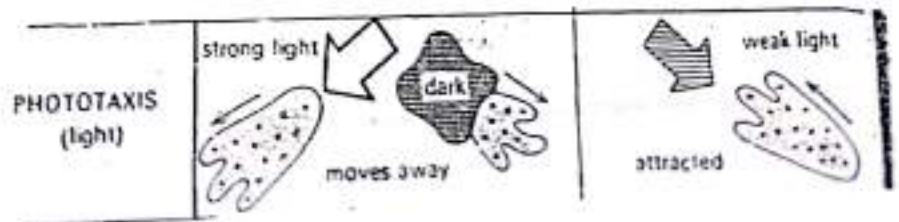
THIGMOTAXIS (touch)	<p>picked with a probe when settled</p> <p>avoided</p>	<p>leaf</p> <p>floating</p> <p>attracted</p>
CHEMOTAXIS (chemicals)	<p>quickly withdraws</p>	<p>food</p> <p>attracted</p>
GALVANOTAXIS (electric current)	<p>anode</p> <p>avoided</p>	<p>cathode</p> <p>attracted</p>
GEOTAXIS (gravity)	<p>floating</p>	<p>settles to bottom and moves away</p>
RHEOTAXIS (water current)	<p>floats along water current</p>	

Fig. 7.15. Amoeba showing reactions to various stimuli. The arrows indicate directions of movement.

Taxis is the simplest type of adaptive and stereotyped behaviour. It can be defined as orientation of an organism to a stimuli. This behaviour is the result of inherited properties of nervous system.

Taxes are most prominent in lower invertebrates. If the orientation is towards the source of stimulus, then it is called positive taxis. If the orientation is away from the stimulus, then it is called negative taxis. Depending on the kind of stimulus, the taxes are of different types.

1. Phototaxis : Light is the stimulus. If an animal moves towards the source of light, then it is called positive phototaxes. Ex: Euglena shows positive phototaxes. If an animal move away from the source of light, then it is called negative phototaxis. Ex: Cockroach show negative phototaxis.



2. **Thermotaxis:** Temperature is the stimulus. *Paramecium* prefers the temperature between 24-28°C. *Amoeba* prefers the temperature between 20-25°C.
3. **Chemotaxis:** The response of animals to the chemical substances is referred as chemotaxis. *Amoeba* shows negative chemotaxis to the strong solution of alkalies.
4. **Geotaxis:** The response of the animals to the gravity is known as geotaxis. Some animals like *amoeba* exhibit positive geotaxis whereas the house fly larva shows negative geotaxis.
5. **Rheotaxis:** The response of an animal to the currents of air or water is called rheotaxis. Ex: *Amoeba* shows negative rheotaxis while *paramecium* shows positive rheotaxis.
6. **Thigmotaxis:** It is the response of an animal to the contact with the environment. Ex: Silver fishes shows positive thigmotaxis.
7. **Klinotaxis:** It is the movement of the animal in response to a stimulus where the animal compares the intensity of the stimulus to lateral side of its body. Ex. It can be observed when light is thrown on Blow fly larva.
8. **Telotaxis :** When two sources of stimulation are given, the animal moves towards one and never in a median direction showing that the influence of one stimulus is ignored. Hermit crab follows any one track when two light sources were projected on it.
9. **Menotaxis:** It depends on complex stimulus and memory of the animal. The hunting digger wasp uses a number of landmarks simultaneously while returning to its nest. Removal of any of the landmark disturbs the hunting digger wasp to find the path of the nest.
10. **Tropotaxis:** A complex case of taxis in which orienting locomotary movement of whole body is influenced by both external stimulation and internal state of the animal. Ex. Tropotaxis present in fishes.

### Kinesis :

Kinesis is a simple form of special orientation. It is unlearned behaviour. It is an innate and stereotyped behaviour. Kinesis can be defined as a **non-directional orientation movement** in which velocity of movement or turning depends on the intensity of a particular stimulus.

There are two kinds of kinesis namely klinokinesis and orthokinesis.

### Klinokinesis :

In this type of behaviour the orientation of the body increases in proportion to the increase in the intensity of the stimulus. For Example *Planaria*, which is found in wet damp, prefers darker places. If it is kept in dim light, it turns occasionally. But when the light intensity is increased, this behaviour of turning increases. Thus klinokinesis behaviour in *planaria* helps to locate a darker place, which it prefers.

### Orthokinesis:

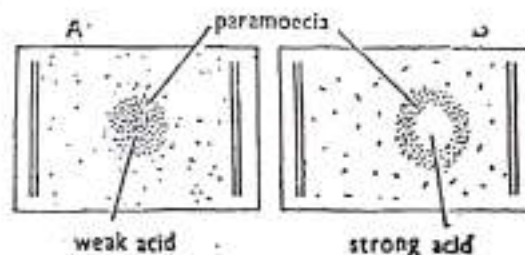


Fig. 10.9. *Paramecium* showing positive reaction to acid.  
 A—Collection of *Paramecia* in a drop of weak acid.  
 B—*Paramecia* forming a ring round a drop of strong acid.

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In this behaviour the speed of locomotion is related to the intensity of stimulation. The non-directional movement of the animal is straight and velocity of its movement is proportional to the strength of the stimulus. Culture of paramecia, taken on a glass slide, move away from a drop of acid. The rate of movement away from acid depends on the concentration of acid. Low concentration of acid induce paramecia to move away slowly but high concentration of acid induce paramecia to move at fast rate.

#### Reflexes :

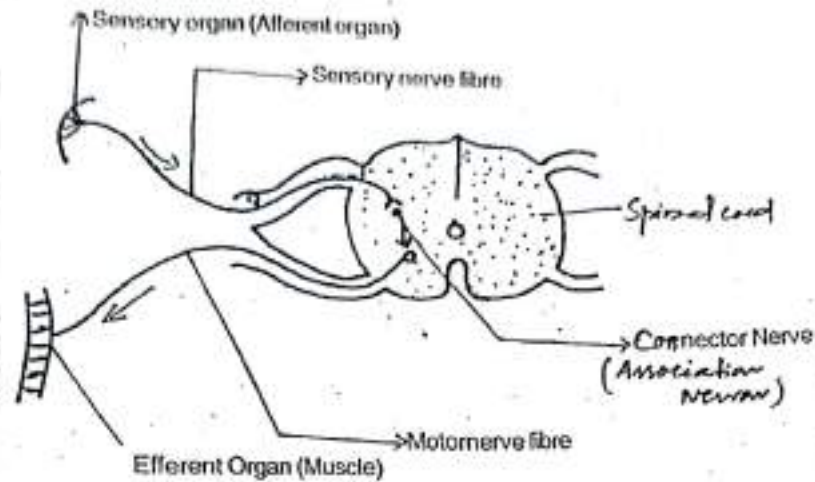


Fig-02: Components of a Reflex Arc

Reflexes automatic, involuntary and stereotyped . They are also innate behaviours and are the outcome of the inherited neural mechanisms. They are the actions made instantaneously by an animal in response to a stimulus.

Reflexes are of two types namely tonic reflexes and phasic reflexes. *Tonic reflexes* are the automatic stereotyped innate responses of the muscles to maintain posture and equilibrium. They help continuously to maintain posture. They are slow, but long lasting the result of continuous adjustments in the body system. *Phasic reflexes* are rapid short-lived adjustments as seen when a pin pricks our hand.

Reflexes may be organized at various levels of nervous system. In the animal kingdom, the reflex response is one of the major modes of adaptations. During evolution, reflexes have undergone changes. They have become more variable and are subject to modified influences. *In a reflex action the reflex arc starts from stimulus and then to receptor-sensory neuron-association neuron- efferent neuron- effector organs and finally response.*

#### Instincts:

Instincts are more complex and most fascinating of the stereotyped or innate behaviour patterns. Instincts do not exhibit fixed patterns in response to stimuli.

Instinct is a genetically inherited character that control animals to behave in a certain fixed ways. Each instinct is initiated by a particular stimulus called sign stimulus or releaser. Instinct is inborn, complex and species specific behaviour patterns. Instinct memory passed on from each generation to its offsprings. Social behaviour, parental care, migration etc. are instinct behaviours.

Ex. Egg rolling behaviour in the greylag goose. The greylag goose builds shallow nest in the ground and it uses a stereotype set of behaviour in bringing back the egg that roll out of the nest. The sight of an egg outside the nest acts as a sign or key stimulus and that elicits egg-rolling behaviour.

In three Spined Stickleback fish, it becomes aggressive and exhibit threat posture, when it see the redbelly of other males.

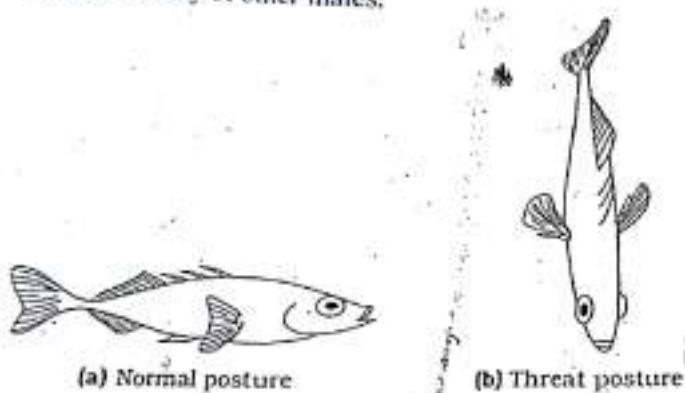


Figure 2.6 Three spined stickle back fish

Herring gulls chick pecks at a red spot present on its parent's bill and that acts as sign stimulus which induces the parent to regurgitate food, called crop milk.

In lower animals instincts are innate responses elicited by combined influences of internal environment and sensory stimulation. For ex: The presence of sex hormones is necessary to bring about sexual behaviour. The stimulus serves only to trigger instinctive behaviour.

### Learning :

Learning is defined as the process that maintains itself by adaptive changes in individual behaviour as a result of past experience .

Learning is a process through which life experiences leave their mark in the form of memory on the individual.

Learning is a process, which cannot be measured directly. However one can evaluate the process of learning by recall or by recognition.

Learning is an acquired behaviour; it is flexible and can be studied under laboratory conditions.

There are different kinds of learning, namely

1. Habituation
2. Imprinting
3. Trial and error

#### **Habituation :**

Habituation is the simplest form of learning. Habituation includes not just the acquisition of new responses but the loss of old ones. Habituation includes the habit of not responding to the stimuli, which do not bring either punishment or reward.

"A gradual decrease in behavioural responsiveness which occurs when a stimulus is repeated frequently with neither reward nor punishment is called habituation".

Scarecrows erected in fields are effective for short time. Birds soon become habituated to this harmless scarecrow. Habituation is present in every group of animals. For example a garden snail moving on a glass slab retracts whenever a tap is made. Gradually the animal will learn that the vibrations and sounds are harmless. Therefore the degrees of response gradually decrease and finally it stops to respond.

The chick pecks at any object on the ground but later it stops pecking at non edible things . Thus the animal gets habituated to the stimuli, which are not their food and stops responding. People living near a railway track sleep without any disturbance but a new comer cannot sleep due to noise.

Habituation is more important kind of learning because it helps the organism to adjust to the environment.

#### **Imprinting:**

Imprinting is a type of learning behaviour. It is highly specialized and limited form of learning.

The phenomenon of imprinting is having the following important attributes:

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1. The individual must be exposed to a model at a certain critical period in its development. This period varies from one individual to another even in a single species.
2. Once the preference is established through imprinting, its effects are irreversible. In some animals imprinting behaviour is not so fixed and are reversible.
3. Imprinting shares the characteristics of both innate and acquired behavioural patterns. For example the ducklings hatched in an incubator did not accept the mother duck, but they preferred to follow human beings instead. If the bird is not imprinted within the critical period of 5hrs to 25 hrs after hatching, it may never imprint at all. Puppies get imprinted on humans and last relationship for a longer time with their owners.

### Trial and error learning:

It is a popular kind of learning behaviour. It is an acquired behaviour.

Trial and error learning can be defined as the development of an association as a result of reinforcement during learning between a stimulus and independent motor action.

In this method the animal is forced with a large number of responses to a given stimulus, where the animal has to choose that response which results in better survival. The animal tries all the responses one by one and ultimately it learns to exhibit the right response.

For example a rat or guinea pig may be placed in a special chamber having several button or levers. The animal gets food only when one particular button is pressed. In this experiment, the animal tries to press all the buttons to get the food. Gradually it will learn to press the particular button, which helps in getting food. Pavlov's work on classical conditioning on Dog salivation is a best example of Trial and Error.

Walking, cycling, driving are all the methods of trial and error learning. The animals learn many activities by trial and error method. This learning is related to stimulations and responses, which helps in survival.

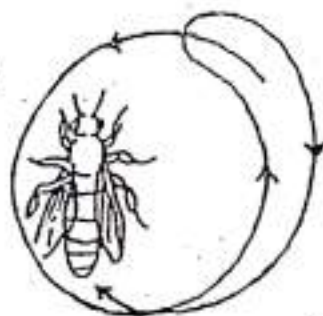
### Animal communication

Communication can be defined as a passage of information from one individual to another individual. Generally the sender will benefit from the response of the recipient. Communication is nothing but the production of a stimulus from one member to bring about the response from another member of the animal society.

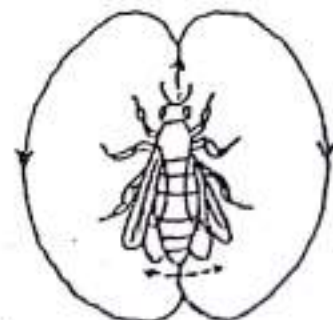
Animals communicate with each other for getting food, shelter, mate, protection etc. communication helps in mutual understanding and mutual benefit.

### Types of communication:

1. Nonverbal communication and
2. Verbal communication.



Round dance



of Honey bees · Waggler dance

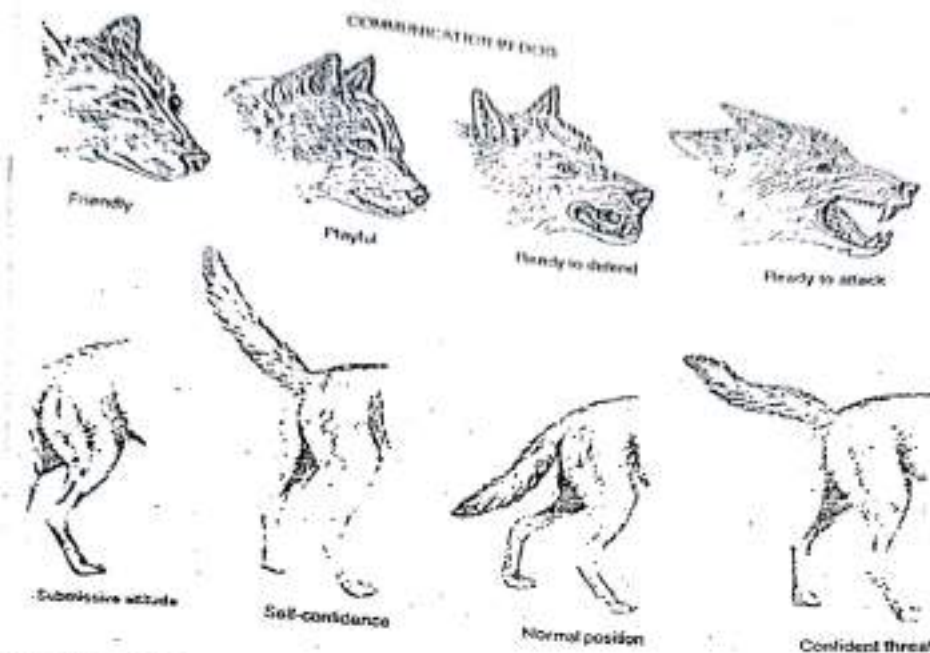


Nonverbal communication :

There are three types of nonverbal communications namely signal communication, chemical or odour communication and bioluminescence.

These modes of communication help in the survival, reproduction and to improve the social organization.

1. Signal or sign communication:



It is a kind of non-verbal communication present in animals. It includes the movement of a part of the body or orientation of the complete body. The sign communication helps in giving a warning signal or threatening signal or alarming signal. The signal is the physical form in which the transmission is passed from one animal to the other. For example threatening posture by the dogs or monkeys. Similarly the submissive posture by the dogs, which have lost the fight.

In gulls, threatening posture includes rising of their head and holding their beaks perpendicularly.

In most animals courtship dance or mating dance includes characteristic movements of the body, which are species specific. Alarming signals are present in some animals to warn the members of the group from the predators or from the dangers.

For example the deer's hit the ground to warn the members of the group about the presence of predator the nearby place.

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Some animals exhibit postures to distract the predators. For example a ringed plover lures a fox away from her chick with broken wing distraction display. This signal helps in saving the chick.

The sign language is used to communicate the place of food by the honeybees. Von Frisch has described the modes of communication in honeybees. There are two types of dances namely round dance and waggle dance. The round dance conveys that they have found a food source and the waggle dance tells the distance and location of food source.

## 2. Odour or smell:

This mode of communication involves the release of chemicals. Each chemical released is used to send a single stable message. The chemicals released may be either hormones or pheromones. Hormones usually affect the physiology of the same organism. But pheromones are released into the atmosphere. They affect the reproductive, developmental and behavioural responses in other members of the same species.

Pheromones are different types:

- a) Releaser pheromones: They cause release effect in the organism, which is a response mediated through central nervous system, it brings about quick behavioural changes in the recipient. For example sex attractants. The female silk moth has a scent gland. The scent released by the glands attracts the male moths up to a distance of about 2 km.
- b) Primer pheromones: They induce a delayed response. It requires a prolonged stimulation through central nervous system and endocrine gland. For example a substance produced queen bee inhibits the development of ovaries in worker bees.
- c) Imprinting pheromones: The substance produced during preweaning periods affects their adults' reproductive behaviour. For example in rats, the young ones reared with their parents mate with the members of different strains.
- d) Trail Pheromones : it is used for guiding the other members of the colony. Ex: ants
- e) Alarm Pheromones s used to warn the others of danger or provoke them 5to attack.

Even in mammals the scent glands are various purposes like marking territory or as sex attractants. The smell of the urine or body sweats gives information to the intruder about the individual present within the boundary and also the reproductive state of the individual. For example the members of the canidae (dog) and felidae (cat) urinate to mark the territory. The faecal material is also used as a scent marker.

## 3. Light or Bioluminescence:

... mainly detected by the  
... present in the  
... pheromones

Light is an effective means of communication in deep-sea animals and some insects. The phenomenon of producing light by the animals is referred as bioluminescence. It is also called cold light. The chemical released for producing light is known as luciferin and the enzyme is called luciferase. Bioluminescence is present in deep-sea fishes, squids and fireflies. Bioluminescence is used as a means of communication to achieve the following objectives:

1. It is used to identify the members of same species.
2. It is used to identify the opposite sex.
3. Bioluminescence is used as a bait to capture the prey as found in Deep sea fishes.
4. In fireflies, it is used to identify and attract the opposite sex.
5. Bioluminescence is used as means of offence and defense.

**Verbal communication or sound communication:** Many animals use sound as a means of communication. There may be variation in pitch and tone. It can be useful for long distance communication, it is effective in forest and underwater.

*Sounds in Invertebrates:*

Many insects produce sounds with the vibrations of wings and legs. The crickets produce sound as a mating call and produce by opening and closing the wings. The cicadas produce sound like musical tones and it is used as a mating call. The mosquitoes also produce a distinct kind of sound during mating dance in the evening hours.

*Sounds in Vertebrates:*



The Sea horse and pipe fishes produce able to make sounds by rubbing their bones. The male frogs produce croaking sound to attract the opposite sex. The cobra produces hissing noise as warning signal. The rattlesnake vibrates its tail to give a warning signal. The lizards also

produce sound to communicate. The birds extensively use sound as a means of communication. They use sound to 'declare their territory, to warn other members or to attract the opposite sex. Ex. Cuckoo.

Mammals also use sound as an effective means of communication. Depending on the pitch of the voice, the sound is used for threatening, for attracting the opposite sex, for communicating or for expressing pain or sorrow. (ex: monkeys and Gorillas) .The ultrasonic sound waves are used by Bat to locate the prey and helps in flight. The whales and Dolphins communicate with each other by whistles.

### **Social organization in primates :**

*A Social organization is a large group of members of same species or population who intercommunicate and shows a permanent relationship to one another.*

Most of the primates are social animals and their organization is stable. The social animals live in groups. They have certain characteristics like dominance hierarchy, grooming, , family bonding, mutual respect, territorial behaviour, mutual protection etc.

#### *Origin and evolution of Social Organization:*

Origin of social Organization may be due to two reasons:

1. The young ones chose to stay with their parents.
2. When two adults chose to stay together

After birth , the children depend on the mother for milk. They need protection and have to learn a number of survival tactics, how to obtain food, who their enemies, social responsibilities, they have to learn communication. On the other hand , the adults would have realized that *two is better than one* . sharing of responsibilities, security and protection against predators . After survived for many years, the social Organization could have originated from small groups to larger ones.

#### *Benefits of Social Organization:*

Better protection, increased chances of foraging, they are more alert to dangers and predators and the young ones will be taken care in society.

#### *Disadvantages Social Organization:*

Increased competition for food, mates, nest, shelter increased risk of diseases, and increased inbreeding will weaken the society.

#### **Features of Social Organization in Monkeys:**

1. Size and composition
2. Territoriality and Aggression
3. Feeding Behaviour
4. Dominance hierarchy
5. Communication
7. Grooming
8. Sexual behavior
9. Parental Care
10. Altruism

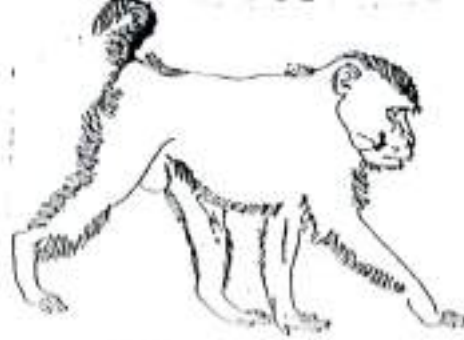


Figure 2.24 Dominant male



Figure 2.25 Subordinate male



Figure 2.26 Female monkey

### 1. Size and composition:

*Bonnet monkeys* or *Asian Macaques* live in groups and their number ranges from 12 to 60. They are mostly terrestrial, diurnal. They are medium sized and covered with hair except on the face. Males are larger than female with distinct canines. They are found in forests, Villages and Cities. The individuals are classified based on their ages and recognized by the colour, *infants*: chocolate coloured hair, *Juveniles*: between 1-2 yrs called *juniors* and between 2-3 yrs called *seniors*, *sub adults* were 3-4 yrs, *adults* were more than 4 yrs and have brown hair on the back and whitish hair on the belly. The groups of Monkeys are called *Troops*.

### 2. Territoriality and Aggression:

Normally monkeys are seen in Banyan Tree and Tamarind trees. They can also spotted in gardens, temples, Schools etc. The *Bonnet monkeys* are not territorial but have a home range which is well marked. The home range could be around 1-3 km. The area of home range depends on the season, food and encroachment by man. The home range include *core area* which provide shelter, *subzones* which occupied by few individuals and *feeding areas*. Normally monkeys shows not much of aggression but scarcity of food brings more aggression and encroachment of other troops shows aggressive behavior.

### 3. Feeding Behaviour:

The bonnet monkeys feed during the mornings and evenings and avoid feeding at night time. They are omnivorous and feed variety of food like seeds, fruits, insects, stem, leaf, roots etc. They store food in cheek pouches and later taken out and chewed slowly.

### 4. Dominance hierarchy:

In monkeys, there is a stable and well-established dominance hierarchy. In every group of such monkeys there will be an alpha leader which will be a male. The crowning of alpha male occurs with threats and fights. The alpha leader has preference to food, shelter and mate. It has the responsibility of protecting the members of the group and also the territory of the group. During mating season its dominance may be challenged by the beta leader. The beta leaders form the second level of hierarchy. They are all males. The young males form the third level of dominance hierarchy. The mother and babies form the fourth level of dominance hierarchy.

During breeding season the beta leaders, which challenge the alpha leader and loose the battle are thrown out of the group. Such males of different groups may join to form their own group called rogue group. These members of the rogue group may attack another group and specially the alpha leader. Sometimes they may replace the alpha leader.

6. **communication:** The members of the troops interact with each other by a number of signals, signs, sounds, odours etc.,. The facial expression are used to convey the feelings. In primates threatening posture includes the opening of mouth widely exhibiting canines and making sound. Sound communication is also effectively used to warn the members of the group during the times of danger. The eye brow movement, jaw thrust, Growl sound , Grr sound are common. They cry loudly in an event of injury.

#### 7. Grooming:

The most common method in monkeys is grooming. It is the cleaning of the body surface by licking, nibbling or scratching. The members may offer to groom the dominant animals or the babies. Auto grooming , Allo, and Mutual Grooming are common. The grooming helps in building up emotional bonding between the members, It reduces aggression, and it is a type of relaxing activity.

#### 8. Sexual behavior and Parental Care

The Bonnet monkeys breed from august to November. Mating is is influenzed by humidity, rainfall and low temperature .The dominant males approach females for copulation. The female turns it back and lifts her tail. The period of gestation is about 150 days. The infants spent 4-6 weeks with their mother. The babies are well cared by the mother and also by other members of troops.

#### 10. Altruism :

It is the kin selection or group selection. The selection aims at saving the fit ones or selected ones so that they live to reproduce and continue the species. In conclusion the social organization in monkeys is well organized and successful one.