Biyani's Think Tank

A concept based exclusive material

Plant Ecology
&
Economic Botany

B.Sc Part-III

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Preface

I am glad to present this book, especially designed to serve the needs of the students. The book has been written keeping in mind the general weakness in understanding the fundamental concepts of the topics. The book is self-explanatory and adopts the “Teach Yourself” style. It is based on question-answer pattern. The language of book is quite easy and understandable based on scientific approach.

Any further improvement in the contents of the book by making corrections, omission and inclusion is keen to be achieved based on suggestions from the readers for which the author shall be obliged.

I acknowledge special thanks to Mr. Rajeev Biyani, *Chairman* & Dr. Sanjay Biyani, *Director* (*Acad.*) Biyani Group of Colleges, who are the backbones and main concept provider and also have been constant source of motivation throughout this Endeavour. They played an active role in coordinating the various stages of this Endeavour and spearheaded the publishing work.

I look forward to receiving valuable suggestions from professors of various educational institutions, other faculty members and students for improvement of the quality of the book. The reader may feel free to send in their comments and suggestions to the under mentioned address.

Author

Syllabus

Unit–I

Plants and Environment : Atmosphere (gaseous composition and properties of four distinct zone viz. stratosphere, troposphere, mesosphere and thermosphere) : water (distribution in biosphere and properties. of water cycle) : Morphological, anatomical and physiological responses of plants to water (Hydrophytes and Xerophytes). Light (global radiation, photosynthetically active radiation. Zonation in water body : littoral, limnetic and profoundal zones; photoperiodism, heliophytes and sciophytes) Temperature (Raunkier's classification of plants: megatherm, mesotherm, microtherm, heikistotherm; themoperiodicity and vernalisation). Soil (soil profile, development-weathering and maturation). Soil texture, soil types, role of PH, organic matter, soil water, soil nutrients. Interactions among organisms (neutralism, amensalism, allelopathy), competition, predation, parasitism,protocooperation, mutualism.Environmental protution act.

Unit–II

Population, Community, Ecosystem and Phytogeography : Population ecotypes, ecades. Community characteristics : stratification, life forms and biological spectrum, frequency density and cover. Ecological succession: types (primary and secondary) mechanism nudation, migration, ecesis, reaction and climax; xerosere, hydrosere; Ecosystems: Structure-abiotic and biotic components, trophic level, food chain, food web, ecological pyramids, energy flow (Box and Pipe model of Odum). Biogeochemical cycles of carbon, and phosphorus; Vegetation types of Rajasthan Endengered plants of Rajasthan.

Unit–III

Basic concept of center of origin of cultivated plants. Food plants-rice, wheat, maize, potato, sugarcane. Vegetables : General account with a note on radish, onion, garlic, cabbage, spinach, cauliflower, cucumber, tomato, lady finger and pea. Fruits: General account with a note on apple, banana, ber, mango mulberry, jamun, watermelon, muskmelon, guava and orange. Vegetable oil : groundnut, mustard and coconut.

Unit–IV

Spices : General account with an emphasis on those cultivated in Rajasthan (Cumin, Capsicum, Coriander).

Beverages : Tea and coffee. Medicinal plants: General accounts with an emphasis on plant species cultivated in Rajasthan (Senna, Isabgol, Safed musli). Fibers: Cotton and jute. Wood : General account of sources of firewood, timber and bamboos; Rubber. Ethnobotany : a general account.

Beverages : Tea and coffee. Medicinal plants: General accounts with an emphasis on plant species cultivated in Rajasthan (Senna, Isabgol, Safed musli). Fibers: Cotton and jute. Wood : General account of sources of firewood, timber and bamboos; Rubber. Ethnobotany : a general account.

Unit 1

Abiotic Factors

Q-1 Discuss the effect of temperature on plant life and their distribution.

Ans. The term temperature, besides the aerial temperature of terrestrial organisms, also includes the temperature of water for aquatic life. Temperature is a measurement for the degree of hotness. The radiant energy received from the sun is converted to heat energy. The degree of hotness or temperature at the point water freezes into ice at 0^{o} C and at the point water boils into steam at 100^{o}C.

Temperature affects plants in various ways, which are as follows:-

(1) Effects on metabolism:

All metabolic processes are influenced by temperature. It affects the rates of transpiration, photosynthesis in plants and respiration rates and other metabolic processes in plants.

Increase in temperature increases the capacity of air to hold more moisture in vapour form. These results in higher difference between vapor pressure deficits and consequently the rate transpiration increases.

Temperature also regulates the activity of enzymes which in turn regulates physiological processes. The temperature at which physiological processes are at their maximum efficiency is called optimum temperature.

(2) **Effects on reproduction:**

Flowering in plants is affected by temperature through thermoperiodism i.e. the response of plant to rhythmic diurnal fluctuations in temperature. Temperature is an important factor in the phenolology of plants (i.e. study of periodical phenomena of plants, at the time of flowering in relation to climate).

(3) Effect on growth and development:

Both extremely low and high temperatures have adverse effect on the growth of plants. Low temperature brings about such cold injuries as desiccation , chilling injury and freezing injury . In desiccation , tissues are dehydrated and injured due to rapid transpiration and slow absorption during winter. Chilling injury is the killing or injury of the plants of hot climate. If exposed to low temperatures, water is frozen into crystals in the intercellular spaces causing injury to cells. This is known as freezing injury. Some perennials can tolerate extremely low temperatures and this ability is called cold resistance. Extremely high temperatures cause stunting and final death of the plants , which is due to adverse effects on a number of physiological processes as respiration , transpiration , protein metabolism etc. This is called heat injury.

Most of the land plants thrive in quite a wide range of temperatures from almost freezing to about 55ºC and these are called eurythermic plants. Aquatic environments usually show less fluctuation in temperature and hence many aquatic plants thrive in a narrow temperature range and these are called stenothermic plants.

Some algae like Chlamydomonas nivalis and diatoms live on snow. Extremes of temperatures, both on cold and hot sides damage the membrane , destroy the proteins , denature thermolabile enzymes thus disrupting nucleic acid metabolism.

Effect of temperature on distribution of plants:

Temperature shows pronounced temporal as well as spatial variations. The type of vegetation both in structure and composition is widely different in hot equatorial belt (warm tropics) relatively cool temperate and the permanently cold polar regions. The most striking difference in these geographical belts is the difference in their temperatures besides light intensity, photoperiod and other ecological factors.

The hot and humid equatorial and tropical regions are full of evergreen forests. These are extremely rich in variety of vegetation and different life forms of plants occupy the aerial space in several layers.

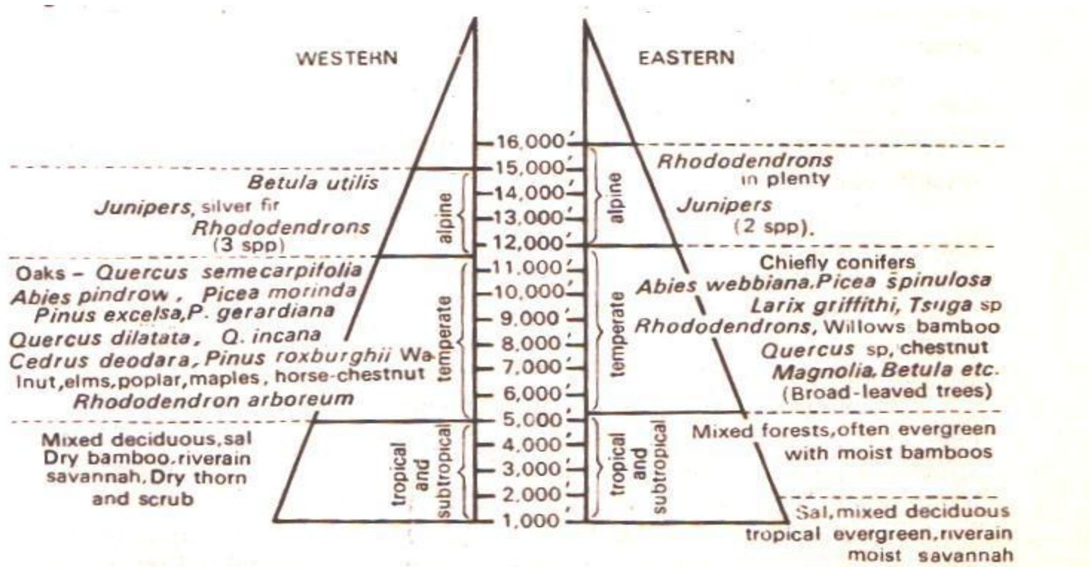
In fact the tropical rain forests are the richest ones in diversity and density. A large variety of dicot trees, shrubs of all stature and size grow intermixed and adjusted compactly in limited space. The temperature belt has low temperature and the region is rich in forests of coniferous trees like pine and deodar and dicot like oaks, birches and chestnuts, Polar region has accounts of extreme cold condition, less free water available due to snow formation. The plants are short and grow sparsely.

Thus, the division of earth's vegetation into different zones, as equatorial, tropical, coniferous, alpine vegetations etc. rests on the marked variations in temperature at different latitudes.

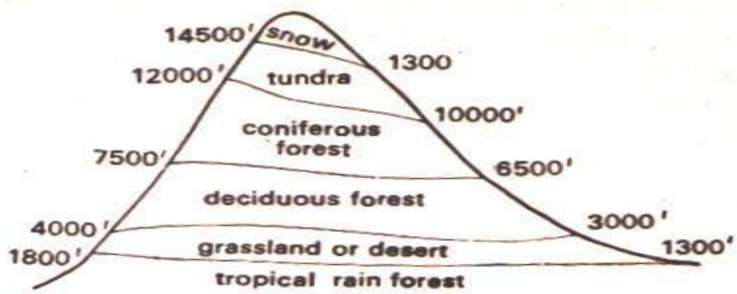
The various zones of different kinds of vegetation at increasing latitudes from equator towards poles (fig) and at increasing altitudes on mountains are more or less similar, showing that increase in latitude and altitude brings about more or less similar influence upon vegetation. Thus, we find distinct latitudinal well as altitudinal zonations in the vegetation.

Xerophytes are more common at lower altitudes and chamaephytes occur at higher altitudes.

In Himalayas, temperature variations are quite evident, and there is a general zonation of vegetation from lower to higher altitudes. The successive zones of vegetation (Fig 4) from base upwards are tropical and subtropical, temperate and alpine.



Altitudinal zonation and distribution of various species of plants on the Western and Eastern Himalayas.



Altitudinal zonation of vegetation on mountains. Note the different types of vegetation with increasing altitude. If compared with Fig. 2, the vegetational types are more or less similar in both.

The lower altitudes in warm and humid Himalayas have rich growth of sal (Shorea robusta), trees with patches of Dalbergia sissoo (Shisum), Eugenia sp. etc. As the altitude temperature falls roughly at the rate of about 7ºC per thousand meters, with the fall in temperature at altitudes above 1500 meters, the temperate species like Pinus roxburghii and species of Quercus incana begin to appear. Further up, around 3000 meters Pinus wallichiana, Cedrus deodara and Abies Pindrow become dominant. The tree height gradually decreases in temperate belts.

Above 4000 meters the growth is almost negligible. Shrubs like Rhododendrons, grasses and several dicot herbs like Saxifraga ,Primula and Anemone replace trees. At above 5600 meters altitude, the temperature falls below the freezing point, all the year round. Under such a snow covered habitat only some highly specialized algae, some lichens, and mosses grow for a short period. Higher altitudes are devoid of vegetation.

Some persons, on the basis of temperature conditions divide world's vegetation into various classes as-

(i) **Megatherms:** Where high temperatures prevail throughout the year and dominant vegetation is tropical rain forest

(ii) **Mesotherms:** With high temperature alternating with low temperature and dominant vegetation is tropical deciduous forests.

(iii) **Microtherms:** Where low temperatures prevail and vegetation is of mixed coniferous forests type, and

(iv) **Hekistotherms:** With very low temperatures and alpine vegetation being dominant.

Q-2 What is environment? Describe the characteristics of various zones of atmosphere?

Ans. The term environment etymologically means surroundings thus; environment is a complex of so many things (light, temperature, soil, water etc.) which surround an organism. Any external force, substance or condition, which surrounds and affects the life of an organism on any way, becomes a factor of its environment. These factors have been variously called as environmental factors, ecological factors or simply factors, and may be living (biotic) as well as non-living (abiotic). The sum of all these living and non-living factors makes the environment of an organism. The place where an organism lives-habitat, indeed presents a particular set of environmental conditions the environmental complex.

All the environmental factors fall into major groups, namely non-living or physical factors and the living or biological factors commonly called biotic factors. The physical factors can be arranged into three groups, namely, (1) Climatic, which relate to the aerial environmental of the plant. (2) Topographic, which relate to the form and behavior of the earth's surface and (3) edaphic or soil factors like physical and chemical nature of the soil which operate within smaller and localized limits (4) the biotic factors are the effects of the activities of other plants, groups and animals including man.

Environmental Factors

Environmental Factors

1. Climatic Factors	2. Topographic factors	3. Edaphic factors	4. Biotic factors
Light	Altitude	Mineral	Plants
Temperature	Surface	Organic component	Animals
Precipitation	slope	soil water & solutes	man
Atmospheric	Exposure	Soil air	
Humidity		Soil organisms	
Wind		soil reaction	

Atmosphere:

The term 'atmosphere' includes only the thick gaseous mantle surrounding the earth. It envelopes the biosphere and overlies both lithosphere and hydrosphere.

Atmospheric gases:

Up to a height of about 300 Km. above the earth's surface, there is present some sort of a thick gaseous mantle. In atmosphere, about 95% of the total air is present up to the height of about 20 Km above earth's surface and the remaining 5% in the rest about 280 Km height. In the gaseous mantle, there is found a mixture of different gases in different proportions. Of these various gases, nitrogen, oxygen and carbon dioxide are the major components.

Besides gases, some other constituents are water vapors, industrial gases, dust and smoke particles in suspended state, micro-organisms. Pollen grains, fungal spores etc.

Atmosphere can be roughly divided into four zones.

(1) Troposphere:

The based part of the atmosphere which is about up to 20 Km above the earth's surface (on poles only up to about 8 Km) is known as troposphere. This is the most important zone of the atmosphere for organisms. The important events such as cloud formation, lightning, thundering, thunder storm formation etc. all take place in troposphere.

Air temperature in this zone gradually decreases with height at the rate of about 6.5ºC per Km. Towards the upper layers of troposphere, the temperature might decrease up to - 60ºC and this limit of troposphere, which gradually merges into the next zone, is known as tropopause.

(2) **Stratosphere:**

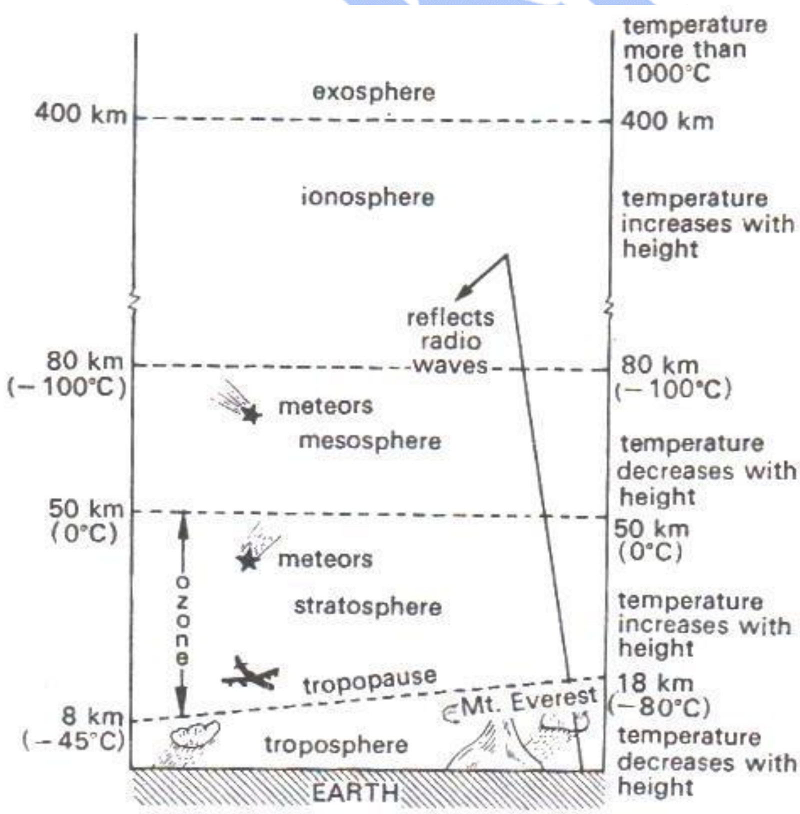
Next to troposphere, the second zone of about 30 Km height is called stratosphere, where the temperature values show an increase up to 90ºC. This increase in temperature is due to Ozone formation under the influence of ultra-violet component of sunlight . Upper layers of stratosphere form stratopause.

(3) **Mesosphere:**

About 40 Km. in height, the zone, next to stratosphere is called mesosphere In this zone, temperature shows again a decrease up to 80ºC. Upper layers of this zone are mesopause.

(4) **Ionosphere:**

The rest above the mesosphere, up to the height of above 300 Km above earth's surface is ionosphere. Most of the gaseous components which become ionized under the influence of radiant energy, remain as ions. Due to their much less density, they are rarely present in molecular form.



Structure of the atmosphere.

Q-3 Write short notes on:-

(a) Edaphic factors

(b) Mutualism

Ans (a) <u>Edaphic factors</u>:

Edaphic factors include the structure and composition of soil along with its physical and chemical characteristics.

<u>Definition and composition of soil</u>:

Soil is defined as "any part of earth's crust in which plants root." Soil is not merely a group of mineral particles. It has also a biological system of living organisms as well as some other components. It is thus preferred to call it as a soil complex, which has the following five categories of components.

(i) <u>Mineral matter</u>:

A matrix of mineral particles derived by varying degrees of breakdown of the parent material rock

(ii) <u>Soil organic matter or humus</u>:

An organic compound derived from long and short term addition of material from organisms growing above and below ground i.e. plants, animals microorganisms.

(iii) <u>Soil water/Soil Solution</u>:

All water contained in soil together with its dissolved solids, liquids and gases. Soil water is held by capillary and absorptive forces both between and at the surface of soil particles.

(iv) <u>Soil atmosphere</u>:

It occupies the pore space between soil particles, which at any time, is not water filled.

(v) <u>Biological system</u>:

Each soil has a distinctive floras as well as fauna of bacteria, fungi, algae, protozoa, rotifers, nematodes, oligochaetes, molluscs and arthropods.

<u>Factors affecting soil formation</u>:

The nature and type of the soil, forming at a particular place is largely governed by the nature of the parent material and its interaction with climate, topography, organisms etc. Joffe sub-divided soil forming factors as follows:-

(I) <u>Passive factors</u>:

(1) **Parent material:**

Its physical constitution influences the soil constitution influences the soil aeration, leaching rate and texture whereas the chemical composition influences the chemical characteristics of soil.

(2) **Topography:**

It influences soil formation through drainage and retention of water. Soil aeration is also governed by topography which affects the solifluction and insulation of chemicals.

(3) **Time:**

(II) **Active factors:**

(1) **Rainfall:**

It determines the direction of solute translocation according to precipitation /evaporation (P/E)) ratio.

(2) **Temperature:**

Through its interaction with precipitation, it governs P/E ratio. Through, its influence on physico - chemical processes, it controls the rate of organic turnover in soil.

(3) **Humidity/Evaporation:**

Their interaction influences rainfall and the amount of water movement.

(4) Wind

(5) **Biosphere effects:**

Living organisms are very important in pedogenesis as they speed up and modify the physico-chemical processes.

(a) Phytosphere:

(i) Direct plant activities such as secretion of organic arid, enzymes, respiratory Co_2

(ii) Input of organic matter after death

(iii) Micrometeorological influence of vegetation cover

(b) Zoosphere:

(i) Direct interaction between primary production and consumption by animals with consequent effect on input of organic matter to the soil.

(ii) Soil dwelling micro-arthropods, molluscs, lumbricids etc have a direct influence on organic matter turnover and incorporation.

Soil Profile:

The different horizons of a soil profile historically in Russian terminology were classified into ABC terminology. It consists of the following five main horizons.

(I) The 'O' horizons:

These are the organic horizons forming above the surface of the mineral matrix, mainly composed of fresh or partially decomposed organic matter. This horizon is well developed in forests and may be completely absent in grasslands. This horizon is divided into following two sub-layers:

(1) O_1 Region:

This is the upper most layer consisting of freshly fallen dead organic matter as dead leaves, branches, flowers and fruits, dead parts of animals etc.

(2) O_2 Region:

It is just below the O_1 region, in which decomposition has begun. Thus organic matter is found under different stages of decomposition and microorganisms like bacteria, fungi, actinomycetes are frequently found.

(II) The 'A' Horizons:

These are the mineral horizons formed either at or adjacent to other surface. These are rich in organic matter and/or show downward loss (eleviation) of soluble salts, clay, iron or aluminum, being consequently rich in silica or other resistant minerals.

(1) A_1 region:

It is dark and rich in organic matter. The amorphous, finely divided organic matter here becomes mixed with the mineral matter, known as humus, which is dark brown or black colored.

(2) A_2 region:

This region is of light colour in which the mineral particles of large size as sand are more, with little amount of organic matter.

(III) The 'B' horizons:

These are the mineral horizons below the surface in which one or more of the following features are present (i) enrichment with inwashed clay (lessivation), iron, aluminium, manganese or organic matter, (ii) residual enrichment with sesquioxides or silicate clays which has occurred other than by the removal of carbonates or readily soluble salts (iii) sesquioxide coatings of mineral grain sufficient to give a more intense colour than horizons above or below.

(IV) The ′C′ horizons

(V) The ′R′ horizons

Soil Conservation:

(1) Biological Methods of Soil Conservation:

(i) Contour forming

(ii) Mulching

(iii) **Crop rotation**: The same crop after year depletes the soil mineral. This is overcome by cutting legumes.

(iv) Strip cropping

(v) Dry farming.

(vi) **Agrostological methods:** Grasses such as Cynodon dactylon are utilized as erosion-resistant plants. They are grown in strips between the crops.

(i) Lay farming

(ii) Retiring lands to grass.

(2) **Mechanical methods:** These methods are used as supplements to biological methods, these are-

(a) Basin Listing

(b) Contour terracing

(i) Channel terracing

(ii) Broad based ridge terrace.

(3) Other methods:

(A) **Afforestation:** Trees as wind breaks are planted in deserts which check the velocity of wind. Windbreaks are planted across the area at 90^o to the prevailing wind. They check the spread of sand dunes or desert conditions or blowing away of the fertile top soil.

(B) **Mutualism:** Mutually beneficial interspecific interactions are more common in the tropics than elsewhere. In such association, there occurs a close and often permanent and obligatory contact more or less essential for survival of each. The two populations enter into some sort of physiological exchange.

(1) Pollination by animals:

Bees, moths, butterflies etc derive food from the nectar, or other plant product and in return bring about pollination.

(2) <u>Dispersal of fruits and seeds</u>: Seeds and fruits are commonly transported by animals. The fruits are eaten by birds, mammals etc. and seeds contained in them are dropped in the excrement at various places.

(3) <u>Lichens</u>: These are examples of mutualism where contact is close and permanent as well as obligatory. Their body is made up of matrix formed by a fungus, within the cells of which an alga is embedded. The fungus makes moisture as well as minerals available whereas the alga manufactures food.

(4) <u>Symbiotic nitrogen fixers</u>: This is a well known example of mutualism, where the bacterium Rhizobium forms nodules in the roots of leguminous plants, and lives symbiotically with the host. Bacteria obtain food from the higher plant and in turn fix gaseous nitrogen, making it available to plant.

(5) <u>Mycorrhizae</u>: Ectotrophic mycorrhizae are very common in nature on pines, Oaks, hickories and beech and endotrophic ones occur in red maple and are common in roots and other tissues of many orchids and members of Ericaceae.

In ectotrophic mycorrhizae, the fungal hyphae are the natural substitutes of root hairs absorbing water and nutrients from the soil

(6) <u>Zoochlorella and Zooxanthellae</u>:

Some unicellular plants, especially algae, known as Zoochlorellae, live symbiotically in the outer tissues of certain sponges, coelenterates, mollusks and worms.

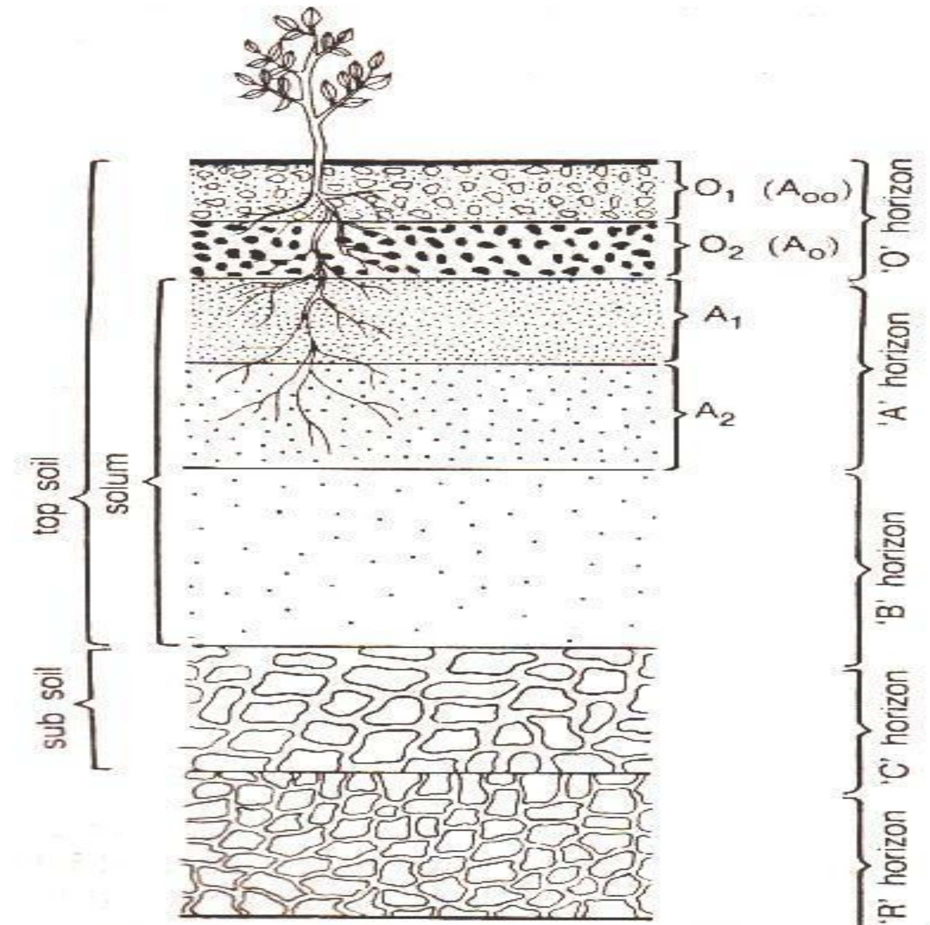
Some brown or yellow cells, probably flagellates (Zooxanthellae) are also present.

Algae are photosynthetic and produce nitrogenous compounds beneficial to hosts and in exchange, they obtain materials released by metabolism of hosts' animals.

The unicellular green alga, Chlorella vulgaris lives within the gastrodermal cells of Hydra. Alga, through photosynthesis provides food and oxygen to Hydra, which in turn provides shelter, nitrogen wastes and Co_2 to chlorella. Similar relationship exists between the alga, zoochlorella and a planarian, Convoluta roscoffensis.

(7) There are associations between animals themselves e.g. termites which feed on wood and the protozoans (species of Trichonympha) present in their guts.

Termites cannot digest cellulose of wood. The protozoans digest cellulose for termites and in return obtain food and shelter from the termite.



Hypothetical diagram of the soil profile to show principal horizons.

CHAPTER-2

Ecosystem

Q.1 Write short notes on followings-

i. Food chains in Ecosystems

ii. Food webs

(i) <u>Food chains in Ecosystems</u>:

The transfer of food energy from the producers, through a series of organisms (herbivores to carnivores to decomposers) with repeated eating and being eating, is known as a food chain.

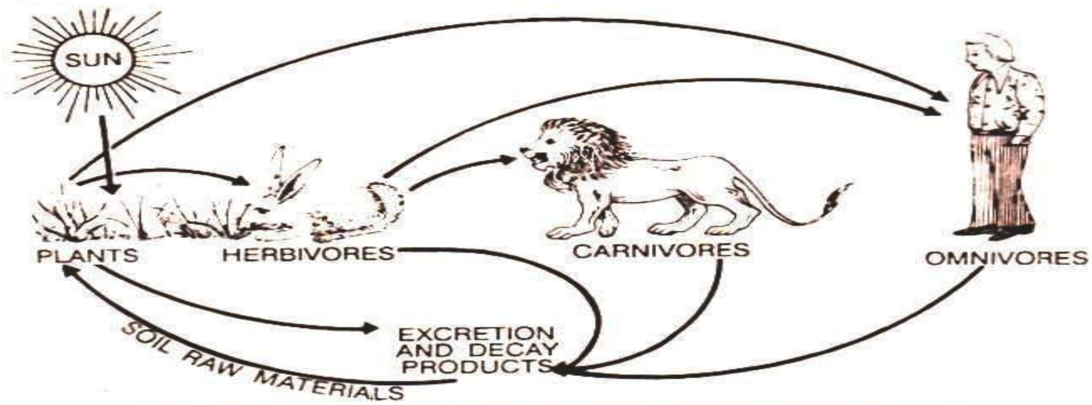
Producers utilize the radiant energy of the sun which is transformed to chemical form, ATP during photosynthesis, thus, in any food chain green plants occupy the first trophic (nutritional) level-the producers level and are called the primary producers. The energy, as stored in food matter manufactured by green plants, is then utilized by the plant eaters - the herbivores, which constitute the second trophic level ------ the primary consumers level and are called the primary consumers (herbivores), Herbivores in turn are eaten by the carnivores, which constitute the third trophic level ___ the secondary consumers level and are called the secondary consumers (carnivores). These in turn may be eaten still by other carnivores at tertiary consumers level i.e. by the tertiary consumers (carnivores). Some organisms are omnivores eating the produces as well as the carnivores at their lower level in the food chain. Such organisms may occupy more than one trophic levels in the food chain.

In nature, there are generally two types of food chains:

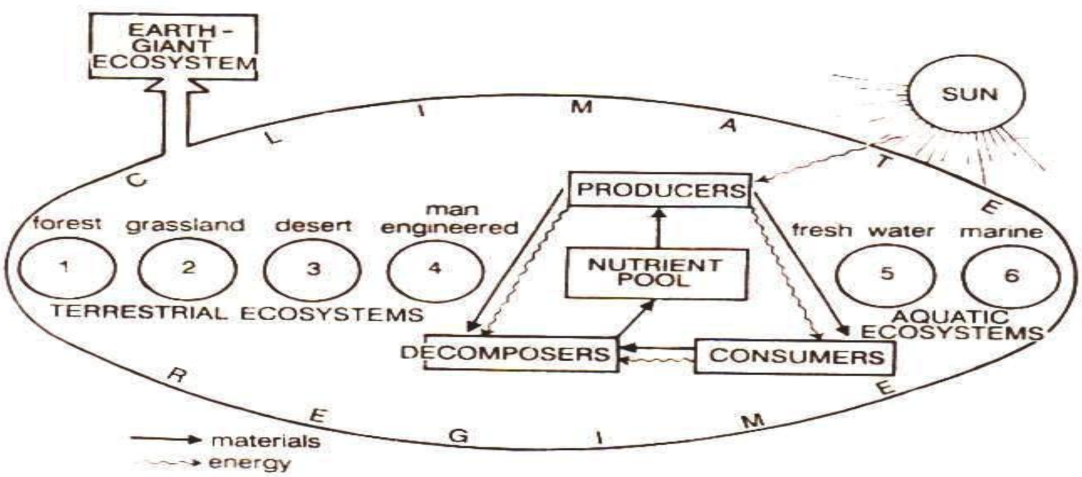
1. **Grazing food chain**: This type of food chain starts from the living green plants, goes to grazing herbivores (that feed on living plant materials with their predators) and on to carnivores (animal eaters). Ecosystems with such type of food chain are directly dependent on an influx of solar radiation. This type of chain depends on autotrophic energy capture and the movement of this captured energy to herbivores . Most of the ecosystems in nature follow this type food chain.

e.g. Phytoplanktons– zooplanktons -fish sequence
or the grasses – rabbit – fox sequence.

2. **Detritus food chain:** This type of food chain goes from dead organic matter into microorganisms and then to organisms feeding on detritus (detritivores) and their predators. Such ecosystems are less dependent on direct solar energy
e.g. such type of food chain operates in the decomposing accumulated litter in a temperate forest. A good example of a detritus food chain is based on mangrove leaves described by Heald (1969) and W.E. Odum (1970).
In the brackish zone of Southern Florida, leaves of the red mangrove ___ Rhizophore mangle fall into the warm ,shallow waters. Only 5% of the leaf material was removed by grazing insects before leaf fall.
The fallen leaf fragments (acted on by such saprotrophs as fungi, bacteria, protozoa etc. and colonized mainly by phytoplanktonic and benthic algae) are eaten and re-eaten (coprophagy) by a key group of small animals. These animals include crabs, copepods, insect larvae, grass shrimps, mysids, nematodes, amphipods, bivalve molluscs etc. All these animals are detritus consumers. The detritivores ingest large amounts of the vascular plant detritus. These animals are in turn eaten by some minnows and small game-fish etc. i.e. the small carnivores, which in turn serve as the main food for larger game fish and fish eating birds which are the large (top) carnivores. The mangroves considered generally as of less economic value make a substantial contribution to the food chain that supports the fisheries, an important economy in that region.



A generalised scheme of nutritional relationships among different biotic components of an ecosystem



Diagrammatic representation of the basic types of ecosystems, all of which together constitute the giant ecosystem—the biosphere. Note, in the centre, the generalised scheme of the structure and function of any unit ecosystem of the biosphere.

<u>Food webs</u>- interlocking pattern of organisms.

In natural conditions, food chains never operate as isolated sequences, but are interconnected with each other forming some sort of interlocking pattern, which is referred to as a food web. Under natural conditions, the linear arrangement of food chains, hardly occurs and these remain indeed interconnected with each other through different type of organisms at different trophic levels.

i.e. in grazing food chain of a grassland, in the absence of rabbit, grass may also be eaten by mouse. The mouse in turn may be eaten directly by hawk or by snake first which is then eaten by hawk.

Thus, in nature, there are found alternatives, which all together constitute some sort of interlocking pattern – the food web.

In a food web, in grassland, five linear food chains can be seen-

i. Grass – Grasshopper -Hawk

ii. Grass - Grasshopper- Lizard –Hawk

iii. Grass – Rabbit - Hawk (or vulture or fox or even man , if present)

iv. Grass –Mouse -Hawk

v. Grass – Mouse – Snake - Hawk

All these five chains are interlinked with each other at different points, forming food web.

The population in African grassland is characterized by their feeding relationships in the following two food chains:

(1) Live grass - wilde beest - Lion

(Producer) (herbivore) (Primary carnivore in chain 1)

(2) Dead grass - Termite - Aardvark

(dead organic matter) (decomposer) (Primary carnivores)

The broken arrows show how the two chains are linked into a food web. Food webs are basic units of ecosystem ecology.

The food webs are very important in maintaining the stability of an ecosystem in nature.

e.g. decrease in the population of rabbit would naturally cause an increase in the population of alternative herbivore, the mouse. This may decrease the population of the consumer (carnivore) that prefers to eat rabbit. Thus, alternatives (substitutes) serve for maintenance of stability of the ecosystem.

The complexity of any food web depends upon the diversity of organisms in the system. It would depend upon two main points:-

(1) <u>Length of the food chain</u>:
Diversity in the organisms based upon their food habits would determine the length of the food chain. More diverse the organisms in food habits, more longer would be food chain.
(2) <u>Alternatives at different points of consumers in the chain</u>:
More the alternatives more would be the interlocking pattern. In deep oceans, seas etc. where we find a variety of organisms the food webs are much complex.

Q-2 Explain the two levels of thermodynamics. Describe box-pipe model of flow of energy in an ecosystem.

Ans. Green plants are the only organisms which fix light energy in the form of food energy. Without them, the light energy is converted into heat energy and cannot be used by living organisms as such. It will only serve to heat the earth. The life of all heterotrophic plants and animals depends on the energy entrapped by green plants in their food molecules. That is why the green plants are called primary producers.

The fixation of solar energy by the photosynthetic plants and its utilization in the form of food by the living organisms obey the two fundamental laws of thermodynamics

(i) According to the first law, energy may be transformed from one type (e.g. light) into another (e.g. food energy) but it cannot be created or destroyed. A common household example of this law is the conversion of electric energy into light and heat energy.
(ii) According to the second law, every transformation of energy is accompanied by a simultaneous degradation of energy from a concentrated form into a dispersed form. In other words, some energy is lost as heat energy .On this account, no transformation of energy (e.g. light energy to food energy) can be 100 percent efficient.

<u>Energy Flow in Ecosystem</u>:

The behaviour of energy in an ecosystem can be termed energy flow due to unidirectional flow of energy. From energetic point of view it is essential to understand for an ecosystem (i) the efficiency of the producers in absorption and conversion of solar energy (ii) the use of this converted chemical form of energy by the consumers (iii) the total input of energy in form of food and its efficiency of assimilation (iv) the loss through respiration, heat, excretion etc and (v) the gross net production.

The principle of food chains and the working of the two laws of thermodynamics can be understood by means of energy flow diagram shown in (fig.) below:-

Single – Channel energy model

As shown in the figure ( ) given below, out of the total incoming solar radiation (118, 872 g cal/cm^2/yr) 118, 761 g cal/cm^2/yr remains unutilized, and thus gross production (net/production plus respiration) by autotrophs is 111 g cal/cm^2/yr with an efficiency of energy capture of 0.10 percent.

21 percent of this energy or 23 g/cal/cm^2/yr is consumed in metabolic reactions of autotrophs for their growth, development, maintenance and reproduction. 15 g cal/cm^2/yr are consumed by herbivores that graze or feed on autotrophs- this amounts to 17 percent of net autotroph production.

The remainder of the plant material 70 g cal/cm^2/yr or 79.5 percent of net production is not utilized at all but becomes part of the accumulating sediments.

Various pathways of loss are equivalent to and account for total energy capture of the autotrophs i.e. gross production .Of the total energy incorporated at the herbivores level i.e. 15 g cal./cm^2/yr, 30 percent or 4.5 g cal/cm^2/yr is used in metabolic reactions. Thus there, considerably more energy lost via respiration by herbivores (30 percent) than by autotrophs (21 percent). There is considerable energy available for the carnivores namely 10.5 g cal/cm^2/yr or 28.6 per cent of net production passes to the carnivores.

At the carnivore level, about 60 percent of the carnivores energy intake in consumed in metabolic activity and the remainder becomes part of the not utilized sediments; only an insignificant amount is subject to decomposition yearly. This high respiratory loss compares with 30 percent by herbivores and 21 percent by autotrophs in this ecosystem.

Thus from the energy flow diagram shown in fig ( ) two things become clear;

(1) There is one way street along which energy moves (unidirectional flow of energy) .The energy that is captured by the autotrophs does not revert back to solar input; that which passes to the herbivores does not pass back to the autotrophs. As it moves progressively through the various trophic levels it is no longer available to the previous level.

(2) There occurs a progressive decrease in energy level at each trophic level. This is accounted largely by the energy dissipated as heat in metabolic

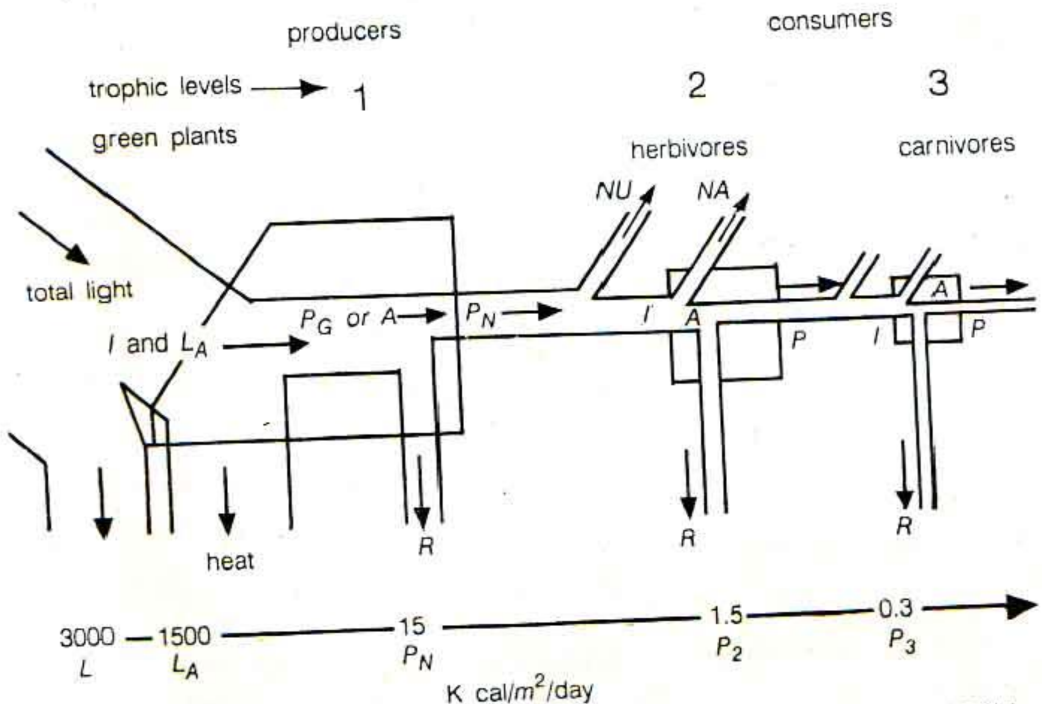


Fig. 11. A simplified energy flow diagram depicting three trophic levels (boxes numbered 1,2,3) in a linear food chain. I—total energy input; LA – light absorbed by plant cover. PG – gross primary production; A – total assimilation; PN – net primary production; P – secondary (consumer) production; NU – energy not used (stored or exported); NA – energy not assimilated by consumers (egested); R – respiration. Bottom line in the diagram shows the order of the magnitude of energy losses expected at major transfer points, starting with a solar input of 3,000 Kcal per square meter per day.

Activities and measured as respiration coupled with unutilized energy.

In the diagram, the "boxes" 1,2,3 represent the tropic levels and the "pipes" depict the energy flow in and out of each level.

Energy inflows balance outflows as required by the first law of thermodynamics and each energy transfer is accompanied by dispersion of energy into unavailable heat (i.e. respiration) as required by the second law.

Thus, it is clear that energy flow is greatly reduced at each successive tropic level from producers to herbivores and then to carnivores. Thus, at each transfer of energy from one level to another, major part of energy is lost as heat or other form. There is successive reduction in energy flow whether we consider it in terms of total flow (i.e. total energy input and total assimilation) or secondary production and respiration components.

Thus, of the 3,000 K cal of total light falling upon the green plants, approximately 50 percent (1500 K cal) is absorbed of which only 1 percent (15 Kcal) is converted at first tropic level. Thus, net primary production is merely 15 K cal.

Secondary productivity (P_2 and P_3 in diagram), tends to be about 10 percent at successive consumer tropic levels i.e. herbivores and carnivores, although efficiency may be sometimes higher, as 20 percent, at the carnivore level as shown (or P_3 = 0.3 K cal) in the diagram.

Thus it becomes evident that there is successive reduction in energy flow at successive tropic levels. The shorter the food chain, the greater would be the available food energy as with an increase in the length of food chain, there is a corresponding more loss of energy.

It is also clear that with a reduction in energy flow (shown as 'pipes' in the diagram) at each successive tropic level; there is also a corresponding decrease in standing crop or biomass (shown as 'boxes' in the diagram). But it never means that there exists any correlation between the biomass and energy.

Y- Shaped energy flow models

Figure (   ) shows two Y- Shaped or 2 – channel energy flow models.

In each Y- Shaped model, one arm represents the herbivore food chain and the other, the decomposer (detritus) food chain. The two arms differ fundamentally in the way in which they can influence primary producers. In each model, the grazing and detritus food chains are sharply separated. This figure contrasts the biomass-energy flow relationships in the sea and the forest.

In the marine bay, the energy flow via the grazing food chain is shown to be larger than via the detritus pathway (forest), whereas the reverse is shown for the forest in which 90% or more of the net primary production is normally utilized in detritus food chain. Thus, in marine ecosystem, the grazing food chain is the major pathway of energy flow whereas in the forest ecosystem, the detritus food chains are more important.

In grazing chain, herbivores feed on living plants and directly affect the plant populations. What they do not eat is available, after death, to the decomposers. As a result decomposers are not able to directly influence the rate of supply of their food.

In a heavily grazed pasture or grassland 50% or more of the net production may pass down the grazing path, whereas there are many aquatic ecosystems, especially shallow water ones that like mature forests operate largely as detritus systems. Since not all food eaten by grazers is actually assimilated, some (undigested material in feces for example) is diverted to the detritus route; thus, impact of the grazer on the community depends on the rate of removal of living plant material as well as on the amount of energy in the food that is assimilated.

Marine zooplanktons commonly graze more phytoplankton than they can assimilate, the excess being egested to the detritus food chain. The energy flow along the different paths is dependent on the rate of removal of living plant material by herbivores as well as on the rate of assimilation in their bodies.

The Y- Shaped model further indicates that the two food chains are not completely isolated from one another under natural conditions e.g. dead bodies of small animals, that were once part of the grazing food chain become incorporated in the detritus food chain as do the feces of grazing food animals.

Thus, the Y- Shaped model is more realistic and practical working model than the single- channel model.

Q-3 **Write short notes on-**

Ans. **(a) Ecological pyramid**

(b) Biotic potential

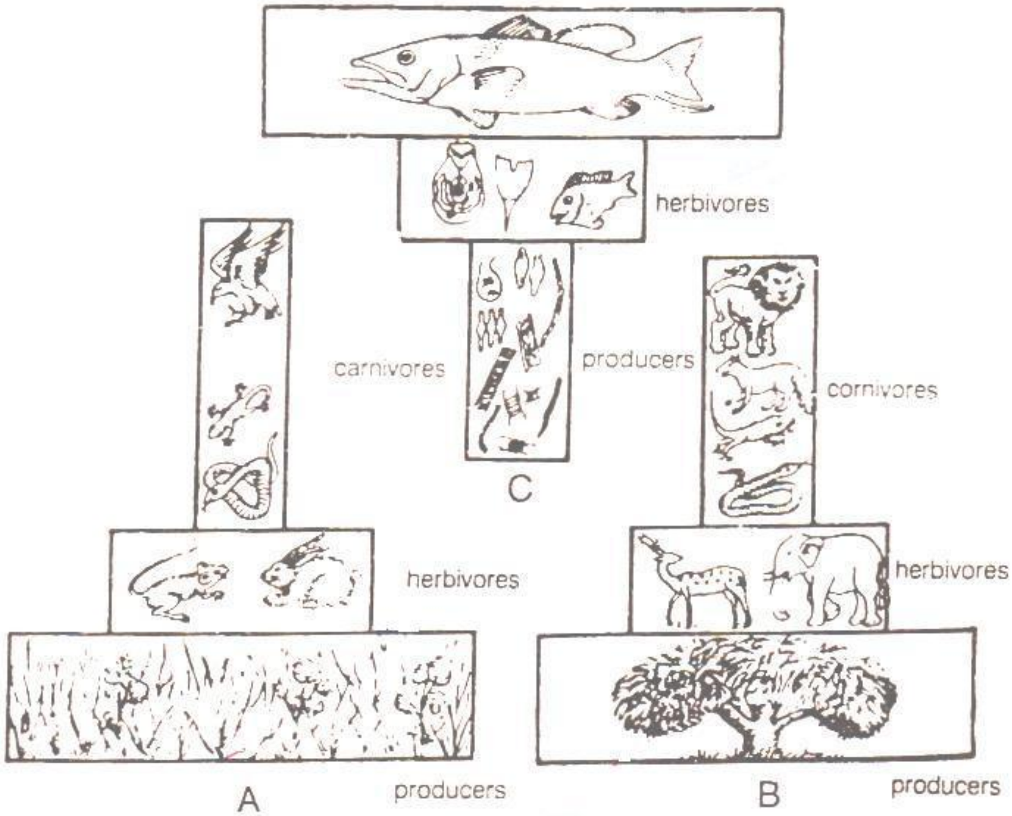
(a) <u>Ecological pyramid</u>:-

Trophic structure i.e. the interaction of food chain and the size metabolism relationship between the linearly arranged various biotic components of an ecosystem is characteristic of each type of ecosystem. The tropic structure and function at successive tropic levels i.e. Producer's → herbivores → carnivores may be shown graphically by means of ecological pyramids, where the first or producer level constitutes the base of the pyramid and the successive levels, the tiers making the apex. Ecological pyramids are of three types-

(1) Pyramids of numbers-

They show the relationship between producers, herbivores and carnivores at successive trophic levels in terms of their number. e.g. in a grassland, the producers which are mainly grasses are always maximum in number. This number then shows a decrease towards the apex , as the primary consumers (herbivores) like rabbits and mice etc are lesser in number than the rabbits and mice. Finally , the top (tertiary) consumers, hawks or other birds are least in number. Thus the pyramid becomes upright. In pond ecosystem , the pyramid is upright . Here, the producers which are mainly the phyto-planktons as algae, bacteria etc are maximum in number, the herbivores, which are smaller fish, rotifers etc are lesser in number than the producers, and the secondary consumers (carnivores), such as small fish eating each other, water beetles etc are lesser in number than the herbivores. Finally, the top (tertiary) consumers, the bigger fish, are least in number.

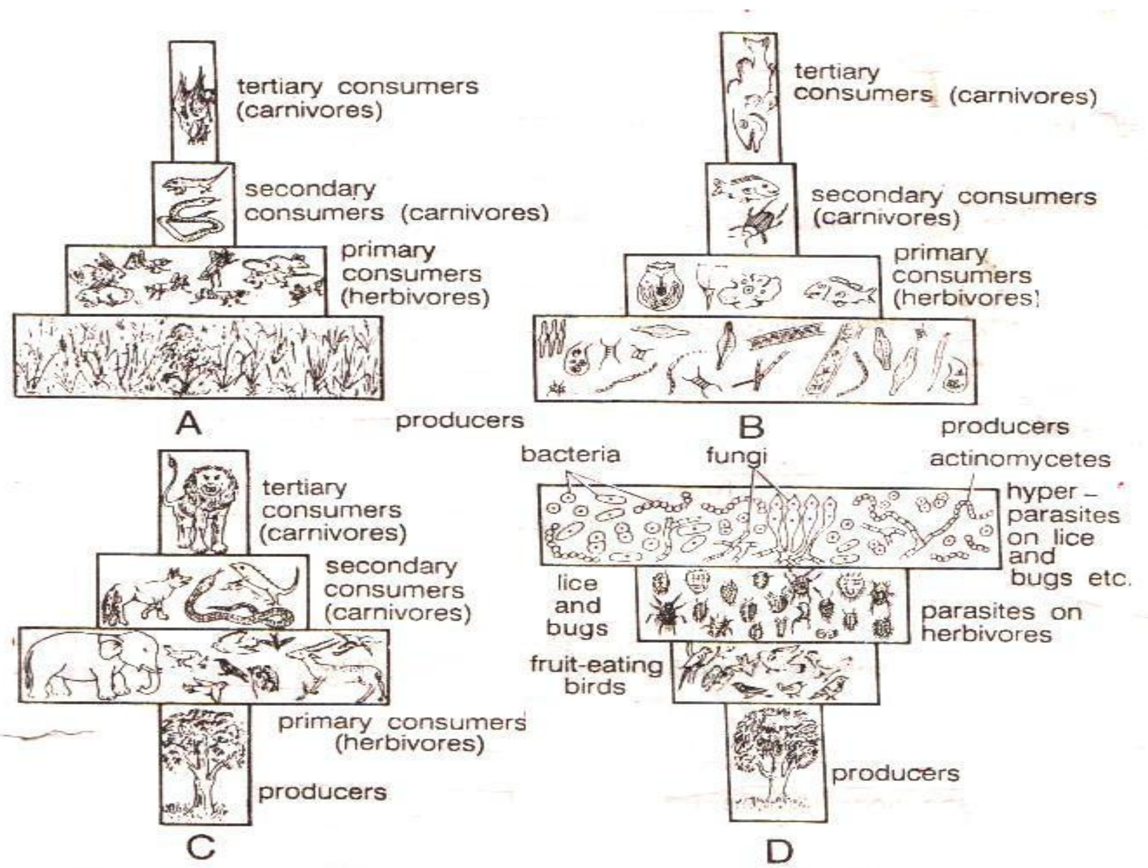
But in forest ecosystem, the pyramid of number is inverted in shape.



(A-C). Pyramids of biomass (g dry wt. per unit area) in different kinds of ecosystems. A – grassland, B – forest, C – pond

(2) Pyramid of biomass-

These show the quantitative relationships of the standing crops. In grassland and forest, there is generally a gradual decrease in biomass of organisms at successive levels from the producers to the top carnivores. Thus pyramids are upright. However, in a pond as the producers are small organisms, their biomass is least and this value gradually shows an increase towards the apex of the pyramid, thus making the pyramid inverted in shape.



Pyramids of numbers (individuals per unit area) in different kinds of ecosystems/food chains A-grassland ecosystem. B – pond ecosystem, C – forest ecosystem. In A-C parasitic microorga ıs and soil animals are not included. D – parasitic food chain.

(3) Pyramid of energy-

Of the three types of ecological pyramids, the energy pyramids give the best picture of overall nature of the ecosystem. Here number and weight of organisms at any level depends not on the amount of fixed energy present at any one time in the level just below, but rather on the rate at which food is being produced.

In shape, it is always upright, as in most cases; there is always a gradual decrease in the energy content at successive trophic levels from the producers to various consumers

(b) Biotic potential:-

Each population has the inherent power to grow. When the environment is unlimited (space, food, other organisms not exerting a limiting effect), the specific growth rate (i.e. the population growth rate per individual) becomes constant and maximum for the existing conditions. The value of the growth rate under these favorable conditions is maximal, is characteristic of a particular population , age structure, and is a single index of the inherent power of a population to grow. It may be designated by the symbol r, which is the exponent in the differential equation for population growth in an unlimited environment under specific physical conditions.

The index r is actually the difference between the instantaneous specific natality rate (i.e. rate per time per individual) and the instantaneous specific death rate and can be expressed as $r=b-d$

The overall population growth rate under unlimited environmental conditions ® depends on the age composition and the specific growth rates due to reproduction of component age groups. Thus , there may be several values of r for a species depending upon population structure.

When a stationary and stable age distribution exists, the specific growth rate is called the intrinsic rate of natural increase or r max.

The maximum value of r is called as biotic potential or reproductive potential. Thus, with this term, one is able to put together natality ,mortality and age distribution. The ranges of the intrinsic rate of natural increase for various kinds of organism are show below-

Intrinsic rate of natural increase:-

Organisms	Approx biotic potential , r (per year)
Large mammals	0.02 – 0.5
Birds	0.05 – 1.5
Small mammals	0.3 ˜8
Large invertebrates	10 – 30
Insects	4-50
Small invertebrates (including large protozoans)	30-800
Protozoa and unicellular algae	600-2,000
Bacteria	3,000-20,000

Chapman (1928) proposed the term biotic potential to designate maximum reproductive power. He defined it as the inherent property of an organism to reproduce, to survive i.e. to increase in numbers.

It is a sort of the algebraic sum of the number of young produced at each reproduction, the number of reproduction in a given period of time, the sex ratio and their general ability to survive under given physical conditions.

But, under natural conditions, this is a rare-phenomenon, since environmental conditions do not permit unlimited growth of any population. Its size is kept under natural check. The difference between the maximum r (biotic potential) and the rate of increase which occurs in an actual laboratory or field condition is often taken as a measure of the environmental resistance, which the sum total of the environmental limiting factors which prevent the biotic potential from being realized.

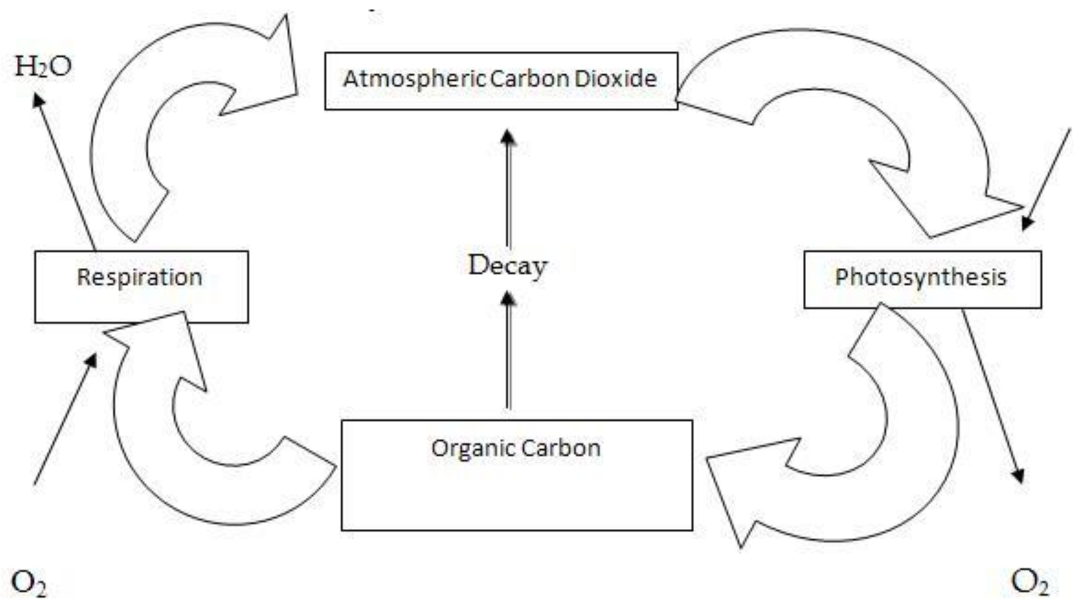
Q-4 Write an essay on Carbon Cycle in nature.

Ans **Carbon Cycle**

Carbon is the basic constituent of all organic compounds. The source of nearly all carbon found in living organisms is carbon dioxide, free in the atmosphere and dissolved in the waters of the earth

The first step in the utilization of Co_2 by living organisms is photosynthesis by green plants. Carbon together with oxygen and hydrogen, in the presence of sunlight is converted into simple carbohydrates. These in turn are synthesized by plants into complex fats and polysaccharides. The polysaccharides and fats stored in plant tissues are eaten by animals, who digest and resynthesize these carbon compounds into others. Meat eating animals feed on the herbivores and the carbon compounds are again re-digested and resynthesized into other forms. Some of carbon is returned to atmosphere directly, since Co_2 is a by-product of respiration of both plants and animals. The carbon locked up in the animal wastes and in the protoplasm of plants and animals is released eventually by decay of organisms.

Bacteria and fungi attack and feed upon plant and animal remnants, breakdown the complex organic compounds into simpler substances, which are then available for another cycle.



Carbon Cycle

The main steps in the carbon cycle in nature are given below:-

(1) Carbon is present as carbon dioxide gas in the atmosphere.

(2) The green plants take up this carbon dioxide gas from the atmosphere and convert it into carbohydrates by the process of photosynthesis. Most of the carbon dioxide enter the living world through the process of photosynthesis. The major process by which carbon-dioxide is removed from the atmosphere is photosynthesis by green plants

(3) Some carbon dioxide is also present in dissolved state in water, so there is a continuous exchange of carbon dioxide between the atmosphere and water bodies like oceans. This carbon dioxide is utilized for photosynthesis by aquatic plants (water plants). Some of this dissolved carbon-dioxide is also trapped to form lime-stone (calcium carbonate, $CaCo_3$) and other carbonate rocks.

(4) The organic compounds prepared in photosynthesis are passed from plants (producers) to the herbivores and carnivores (animal consumers). The green plants and their products are eaten up by animals as food. So carbon in the form of plant carbohydrates travels as food to the animals in successive trophic levels.

(5) Carbon dioxide returns to the atmosphere through respiration of plants and animals , decay of dead bodies of plants and animals, and

combustion of fossil fuels. When the plants and animals undergo respiration, they give out carbon dioxide.

Again, when the dead plants and animals decay (decompose), they produce carbon dioxide. The carbon dioxide produced by respiration and decay of plants and animals is returned to the atmosphere.

(6) The micro-organisms called decomposers play an important role in converting dead organisms (dead plants and animals) into carbon dioxide and returning it to the atmosphere.

Thus, plants and animals release carbon-dioxide to the atmosphere as a by-product of respiration, as well as a result of decay of their dead bodies. In this way, a part of the carbon cycle is completed in nature.

(7) Besides this, the animal waste products like urine also release carbon dioxide on decomposition by micro-organisms.

(8) Some of the dead plants and animals which get buried deep under the earth escape oxidation and change into fossil fuels like coal and petroleum through slow chemical changes. Petroleum gives us fuels like kerosene, petrol and diesel.

(9) When the fuels are burnt they produce carbon dioxide. Thus, carbon dioxide is also returned to the atmosphere through the combustion of various fuels like coal, wood, natural gas, petrol, kerosene, diesel etc.

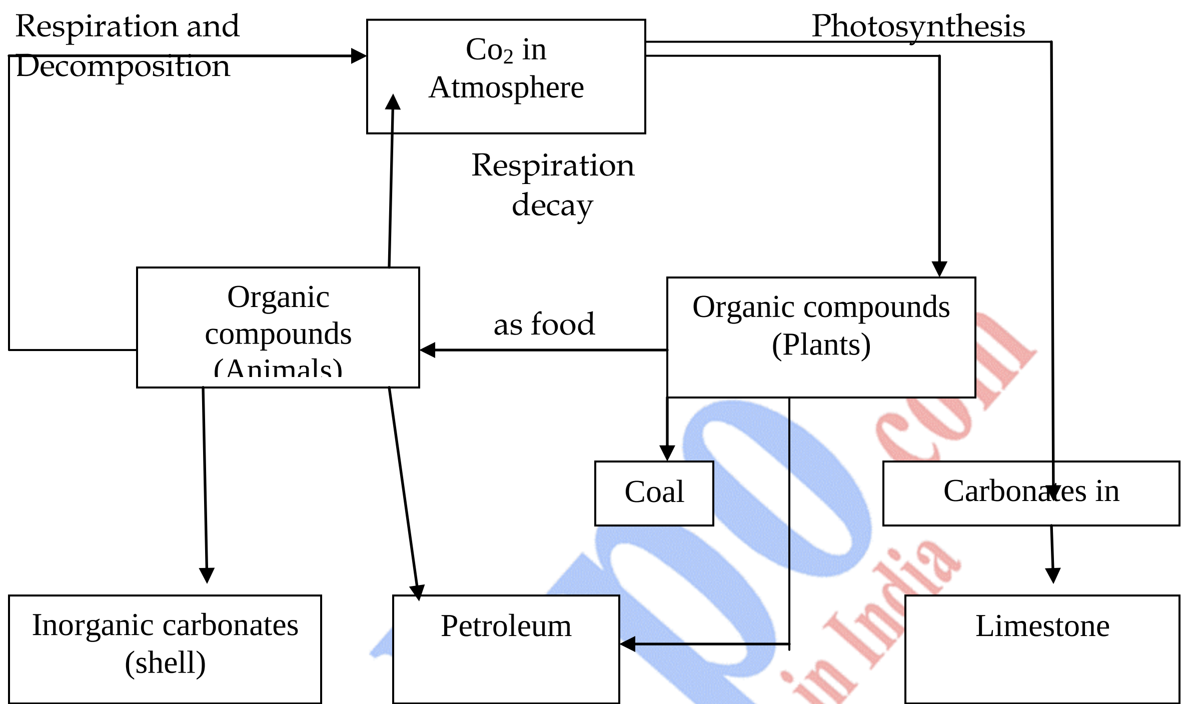
Thus, a carbon cycle (also known as carbon dioxide cycle) is operating in biosphere, as a result of which the proportion of carbon dioxide in the atmosphere remains almost the same.

(10) Volcanic eruptions also release carbon dioxide gas to the atmosphere. This carbon dioxide comes from the decomposition of carbonate minerals buried under the earth.

(11) Carbon dioxide is also released into the atmosphere when acid rain falls on the carbonate rocks such as that of limestone or on inorganic carbonate shells.

(12) The carbon of limestone and other carbonate rocks is also slowly converted to carbon dioxide by the acid produced and excreted as a result of the metabolic processes of soil micro-organisms and plant roots.

In this way, the carbon cycle in nature is completed.



Flow Diagram of Carbon Cycle in nature

Q-5 What are xerophytes? Describe their adaptations with suitable examples.

Ans. The term 'Xerophytes' has been defined and interpreted variously

According to Daubenmire xerophytes are 'plants which grow on substrate that usually become depleted of growth water to a depth of at least 2 decimeters during a normal season.'

Thus, in arid zones, all plants not confined to the margins of streams or lakes have been considered as xerophytes, whereas in regions of heavy rainfall the class would be represented only by shallow rooted plants of sandy soils, by plants of dry ridge tops and by algae, mosses and lichens which grow on tree barks or rock surfaces etc.

On the basis of their morphology, physiology and life cycle pattern. ,Xerophytes are generally classified into the following three categories:

(I) Ephemeral annuals:

They are also called as 'drought evaders' or drought escapers. They are mostly found in arid zones. They are annuals which complete their life cycles within a very short period of 6-8 weeks or so. With their small size and large shoots in relation to roots they are well adapted to such dry habitats. They actually avoid and not withstand dry seasons and thus escape dryness in external and internal environments. Some do not prefer to call them true xerophytes e.g. Argemone mexicana, Solanum xanthocarpum, Cassia tora

(II) <u>Succulents</u>:

They are the plants that suffer from dryness in external environment only. Their succulent, flesh organs (stems, leaves, roots) serve as water storage organs which accumulate large amount of water during brief rainy seasons. In cacti the root systems also become shallow. Their root system is shallow, stem swollen and leaves thick , leathery and succulent.

e.g. Aloe, Euphorbia, and Opuntia and various Cacti, Agave and Ceika parviflora. As the succulents avoid drought, some prefer to exclude them from true xerophytes.

In some of them, stems become succulent, which are also called the fleshy xerophytes 'as in Opuntia and Euphorbia. In such xerophytes, cuticle is thick and well developed, hypodermis is two to three layered, collenchymatous cortex is also thick-walled with chlorenchymatous cells, below, which there is present a prominent 'water storage region'. whose cells are thin-walled with a few intercellular species?

These succulent xerophytes in which leaves become fleshy are also known as 'malacophyllous xerophytes' such as Aloe, Begonia, Salsola' Bryophyllum, Agave, Yucca, Tradescantia etc.

(III) <u>Non-succulent perennials</u>:

These are actually the three xerophytes or drought resistant's, because they possess a number of morphological, anatomical and physiological characteristics which enable them to withstand critical dry conditions.

They are the plants that suffer from dryness both in their internal as well as external environments.

e.g. Calotropis procera , Acacia nelotica, Zizyphus jujuba and Capparis aphylla. Others examples are Prosopis, Casuarina, Nerium, Alhagi, Saccharum and Salvadora.

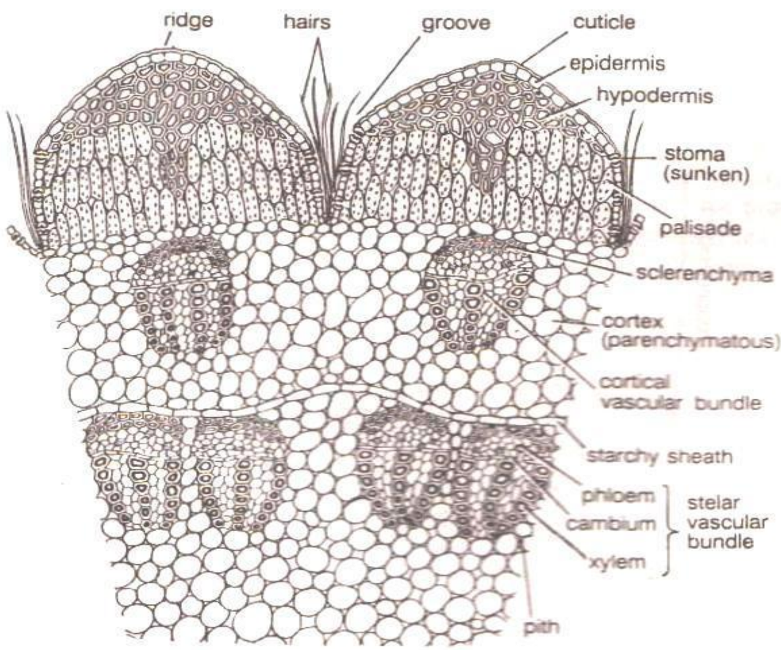


Fig. 16. T.S. stem (a part) of *Casuarina*. Note, the thick cuticle; sunken stomata, confined only to grooves; presence of hairs in grooves; sclerenchymatous hypodermis; green palisade region of subhypodermal cortex; well-developed vascular and mechanical tissues.

Ecological adaptations in xerophytes:

Morphological features

(1) Roots:

Xerophytes develop under water-deficient conditions. Thus in order to secure water, which is present in less amount, in deeper layers of soil, roots in xerophytes become the principle organs of primary importance. Thus, the root system is very well developed, with the following characteristics-

(i) It is very extensive, which in some cases is several times longer than the shoot. Roots are long, tap roots, with extensive branching spread over wide areas.

(ii) Root hairs and root caps are very well developed.

(2) Stems:

(i) Mostly, they are stunted, woody, dry, hard, ridged and covered with thick bark.

(ii) In Saccharum the stem becomes underground, whereas in Opuntia it becomes fleshy, green leaf like (phylloclade) covered with spines. In Euphorbia, it becomes fleshy and green.

(iii) On stems and leaves, there are generally hairs and/or waxy coatings.

Leaves:

(i) Leaves are very much reduced, scale-like appearing only for a brief period, sometimes modified into spines. Lamina may be long, narrow or needle like as in Pinus or divided into many leaflets as in Acacia.

(ii) Foliage leaves, wherever present, may become thick, fleshy and succulent or tough and leathery in texture.

(iii) Leaf surfaces are generally shiny and glazed to reflect light and heat.

(iv) In some monocots, as Ammophila, Poa and Agropyron, leaves become folded and rolled in such a manner that the sunken stomata become hidden, and thus rate of transpiration is considerably minimized.

(v) In some of them as Euphorbia, Acacia nelotica, Zizyphus jujuba and Capparis aphylla.. Stipules become modified into spines.

Anatomical features:

(1) **Roots**- (i) Root hairs and root caps are well developed. In Opuntia root hairs develop even at the root tips.

(2) Roots may become fleshy to store water as in Asparagus.

(3) In Pinus edulis and Calotropis, roots possess rigid and thickened walls.

(4) **Stems:**

(i) In succulent xerophytes, stems posses a water storage region.

(ii) In stems of most of the non-succulent xerophytes such as Casuarinas, the following characteristics are found-

(a) Cuticle is very thick.

(b) Epidermis is well developed with heavily thickened cell walls.

(c)Hypodermis is several-layered and sclerenchymatous.

(d) Stomata are of sunken type

(e) Vascular tissues are very well developed, differentiated, and heavily lignified.

(f) Mechanical tissues are very well developed.

(iii) Bark is very well developed.

(iv) Oil and resins are often present.

(3) Leaves:

(i) In succulent leaves of malacophyllous xerophytes, such as Peperomia , epidermal cells of leaves serve as water-storage organs.
Similarly, succulent leaves of Aloe and Salsola have prominent water-storage regions in their mesophyll.

In such leaves, cuticle is thick and outer walls of the epidermal cells are heavily deposited with cutin and cellulose.

(ii) Leaves of non-succulent xerophytes, such as Nerium and Pinus possess:

(a) Well developed heavy cuticle

(b) Several-layered epidermis in Nerium, and several- layered sclerenchymatous hypodermis in Pinus.

(c) Mesophyll very well differentiated into palisade and spongy parenchyma

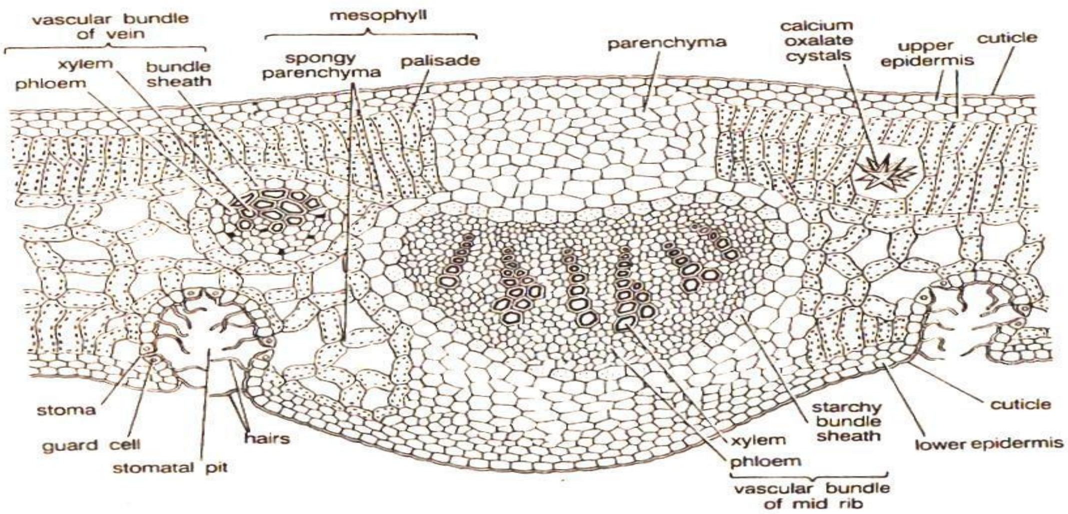
(d) Stomata of sunken type confined only to lower epidermis. In some xerophytes as Nerium stomata are situated in pits lined with hairs.

(e) Vascular tissues are very well developed, differentiated into xylem with lignified elements and phloem.

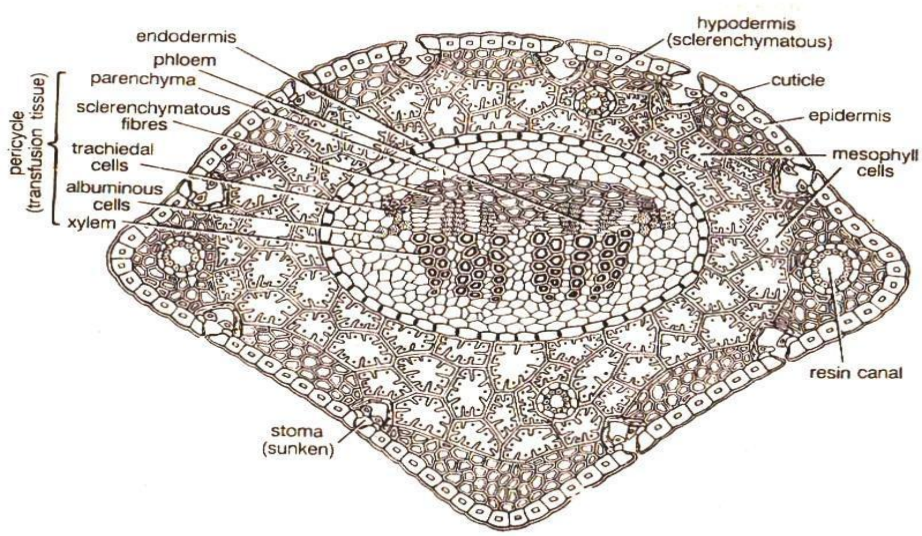
In Nerium, in addition to big vascular bundle in mid-rib region, there are several other vascular bundles also.

(f) Mechanical tissues are very well developed, including several kinds of sclereids. In Pinus, there is well developed complete transfusion tissue.

(iii) In some non-succulent xerophytes, particularly grasses as Ammophila, Poa and Agropyron, leaves become rolled and/or folded in such a manner that the stomata occupy a hidden position, thus minimizing the rates of transpiration. Moreover, their epidermal cells remain mostly turgid.



T.S. leaf of *Nerium* (non-succulent perennial). Note, thick cuticle on both sides, multiseriate epidermis; stomata of sunken type, moreover situated inside the stomatal pits, confined only to lower epidermis; well differentiated mesophyll with palisade on both the sides though abundant on the adaxial one; vascular tissues well-differentiated.



. T.S. needle of *Pinus roxburghii* (non-succulent perennial). Note, thick cuticle; thick-walled epidermis; sclerenchymatous hypodermis; sunken stomata; mesophyll cells with infoldings; complex transfusion tissue; well developed vascular tissues with abundance of xylem elements.

Q-6 What is succession? Describe the succession in rocks.

Ans. Environment is always kept on changing over a period of time due to –

(i) Variations in climatic and physiographic factors and

(ii) The activities of the species of the communities themselves.

These influences bring about marked changes in the dominants of the existing community, which is thus sooner or later replaced by another community at the same place. This process continues and successive communities develop one after another over the same area, until the terminal final community again becomes more or less sable for a period of time.

This occurrence of relatively definite sequence of communities over a period of time in the same area is known as ecological succession.

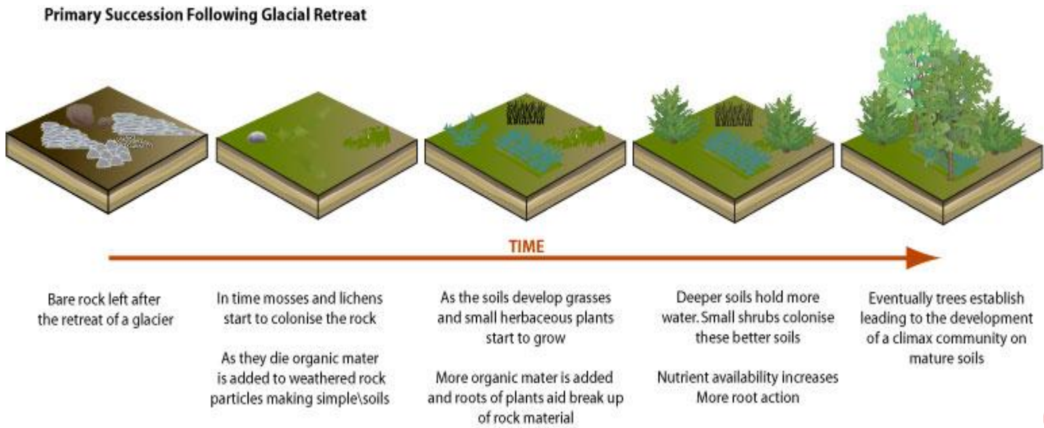
Hult, studied communities of Southern Sweden and used for the first time the term succession for the orderly changes in communities

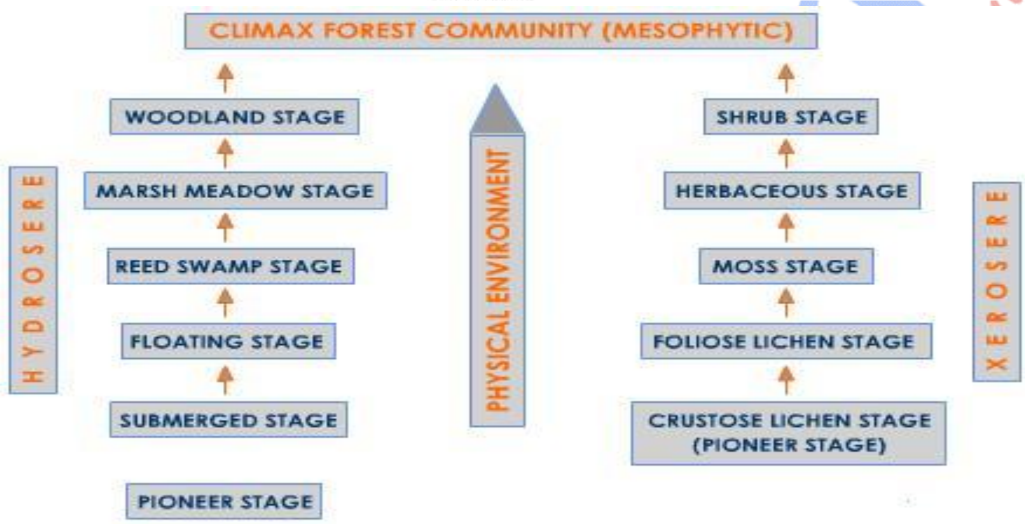
According to Odum: "Ecosystem development or what is more often known as ecological succession, may defined in terms of the following three pare-meters

(1) It is an orderly process of community development that involves changes in species structure and community processes with time, it is reasonably directional and predictable.

(2) It reselects from modification of the physical environment by the community that is succession is community controlled even though the physical environment determines the pattern, the rate of change and often sets limits as to how far development can go.

(3) It culminates in a stabilized ecosystem in which maximum biomass (or high information content) and symbiotic functions between organisms are maintained per unit of 'available energy flow'





A diagrammatic respresentation of the developmental stages of plant succession during hydrosere and xerosere(lithosere) leading to the formation of mesophytic climax forest community

<u>Succession in rocks</u>

<u>Lithosere –</u> A Xerosere on rock.

This is a type of xerosere originating on bare rock surface. The original substratum is deficient in water and lacks any organic matter, having only minerals in disintegrated unweathered state. The pioneers to colonize the primitive substratum are Crustose type of lichens, and through a series of successive seral stages, the succession finally terminates into a forest which constitutes the climax community.

The various stages and their component plant species of a lithosere appearing on a rock are:-

(1) <u>Crustose lichens stage</u>:-

The substratum colonized by these pioneers is very poor in moisture and organic matter, subjected with extremes of temperature. The lichens of this stage are species of Rhizocarpon, Rinodina and Lecanora. They produce some acids which bring about weathering of rocks. The dead organic matter of lichens becomes mixed with the small particles of rocks. However, this process is very slow.

(2) <u>Foliose lichens stage</u>:

They appear on the substratum partially built up by the Crustose lichens. This community includes species of Parmelia, Dermatocarpon etc. which have large leaf-like thalli. They can absorb and retain more water and are able to accumulate dust particles which help in the further build up of the substratum. Thus, some humus becomes accumulated.

The weathering of rocks and its mixing with humus results into the development of a fine rock layer on rock surface, and thus there is a change in the habitat.

(3) <u>Moss stage</u>:

The development of thin layer on rock surface especially in the crevices, favours the growth of some such xerophytic mosses as species of Polytrichum. Tortula and Grimmia. At their successful growth, they compete with the lichens. Due to their death and decay there is further addition of organic matter in the soil. The thickness of the soil layer now increases.

(4) **<u>Herbs stage</u>**:

More and more soil accumulates as the mosses become more extensive. The soil is brought in from surrounding areas by wind. More mineral material is added to the soil as acids leach out from the overlying vegetation. Many herbaceous annual weeds develop which are followed by biennials and finally by perennial grasses.

With the dominance of grasses, animals like nematodes and larval insects and ants and mites appear. Due to the growth and death of annuals, biennials and perennials there is much more accumulation of humus in soil together with further weathering of rock. Thus habitat changes with decreasing xeric conditions.

This stage is constituted by such shallow rooted grasses as Aristida, Festuca, Poa, Solidago etc. which in turn are replaced by shrubs.

(5) <u>Shrub stage</u>:- Due to much accumulation of soil, the habitat becomes suitable for shrubs which start migrating in the area. These are species of Rhus, Phytocarpus etc. They overshadow the herbaceous vegetation. The soil is further enriched by this dense shrubby growth. These in turn are finally replaced by trees which make up the climax community.

(6) <u>Forest Stage</u>: or <u>climax forest</u>:

(7) Some xerophytic tree species invade the area. Further weathering of rocks and increasing humus content of the soil favour the arrival of more trees and vegetation finally becomes mesophytic. Thus, there develop finally a forest community.

The various stages of a lithosere and the chief component plant species appearing at each stage are shown below:

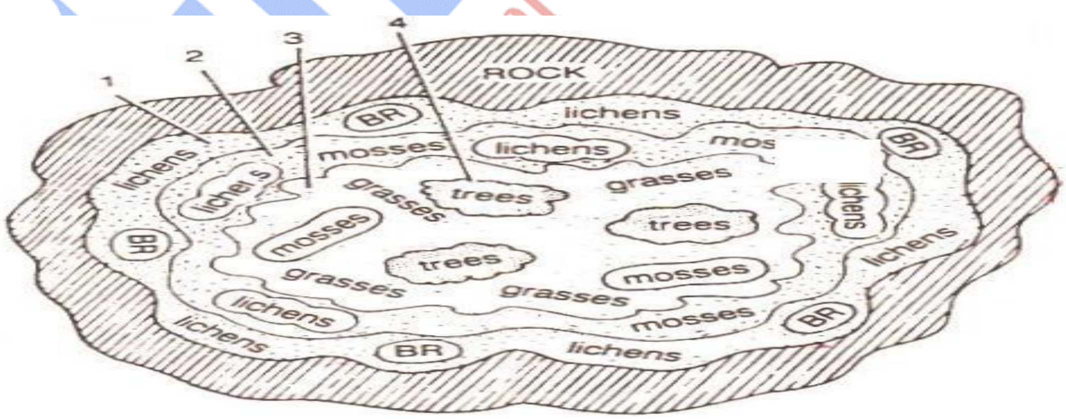
Succession

Succession

Pioneer Community	Seral Communities				Climax Community
(1) Crustose lichens stage	(2) Foliose lichens stage	(3) Moss stage	(4) Herbs stage	(5) Shrub stage	(6) Forest stage
Rhizocarpon	Parmelia	Polytrichum	Aristida	Rhus	Mesophytic
Rinodina	Dermatocarpon	Tortula	Festuca	Phyto- carpus	plants
Lecanora		Geimmia	Poa		

General trend of Succession

—The trend of succession on a rock—



Diagrammatic representation of different plant communities of a lithosere appearing on a rock. Note the vegetational zonation showing the poineer community of lichens around the outer edge and more advanced stages of trees located in the centre. The various zones from outside towards the centre of rock are (1) lichens (pioneers), (2) ring of mosses, (3) grasses (broad zone), and (4) trees (seedlings) scattered. BR- bare rock.

Changes in animal life during lithosere:

During the lithosere, there occur successive changes in animal life. Associated with the lichens, the pioneers are a few mites. There are a few ants and few spiders present in the cracks and crevices of rock. These are the pioneer animal species which are exposed to harsh environment – the thermal extremes etc.

The mites become more varied in terms of species and small spiders, springtails as well as tradigrades become associated with the secondary community of mosses.

At later stage of succession and when grasses start developing, the fauna undergoes a quantitative and qualitative increase. Nematodes and larval insects, Collembola, ants, spiders and mites appear in this new environment. With the development of forest climax community, there develop a rich fauna consisting of invertebrates as ants ,sow bugs, springtails, mites; squirrel's shrews, mammals like fox, chipmunk, mouse and mole, birds like grouse and flycatcher, reptiles like skinks, turtles, snakes etc and amphibians such as salamanders and frogs.

UNIT-3

Plant Succession & Adaptations in Plants

Q-1 Write an essay on Hydrosere or Hydrarch-

Ans

This process of succession occurs in pond. Hydrosere, originating in a pond, starts with the colonization of some phytoplankton's which form the pioneer plant community, and finally terminates into a forest, which is a climax community together with their chief components of vegetation.

These various stages together with their chief components of plant species of a hydrosere are as follows:

(1) Phytoplankton stage:

They constitute the pioneer community. Some blue green algae, green algae, diatoms and bacteria etc are the first organisms to colonize the primitive medium of the pond. The soils are very much reduced with a pH value of not more than 5.00. They multiply and grow for some time.

(2) Rooted Submerged stage:

As a result of death and decomposition of phytoplankton's and their mixing with the silt, brought from the surrounding land by rain waters and by wave action of pond water, there develops a soft mud at the bottom of pond. This new habitat which is shallower and where light penetration may occur easily becomes now suitable for the growth of rooted submerged hydrophytes like Elodea, Hydrilla Potamogeton, Vallisneria, Utricularia etc. These plants bring about further build up of the substratum as a result of their death and decay. The water level also decreases making the pond more shallower.

(3) Rooted floating stage:

These plants colonize the habitat with their rhizomes. They are all rooted hydrophytes with their large leaves floating on the water surface. These are species of Nelumbo, Nymphaea, Trapa, Aponogeton, Monochoria etc.

Some free-floating species as Azolla, Lemma, Wolffia, Pistia, Salvinia, Spirodella etc. also become associated with the rooted plants due to availability of salts and other minerals in abundance. By now, the water level becomes very much decreased making the pond shallower; the decomposing organic matter formed due to death of these plants brings about further build up of the substratum .

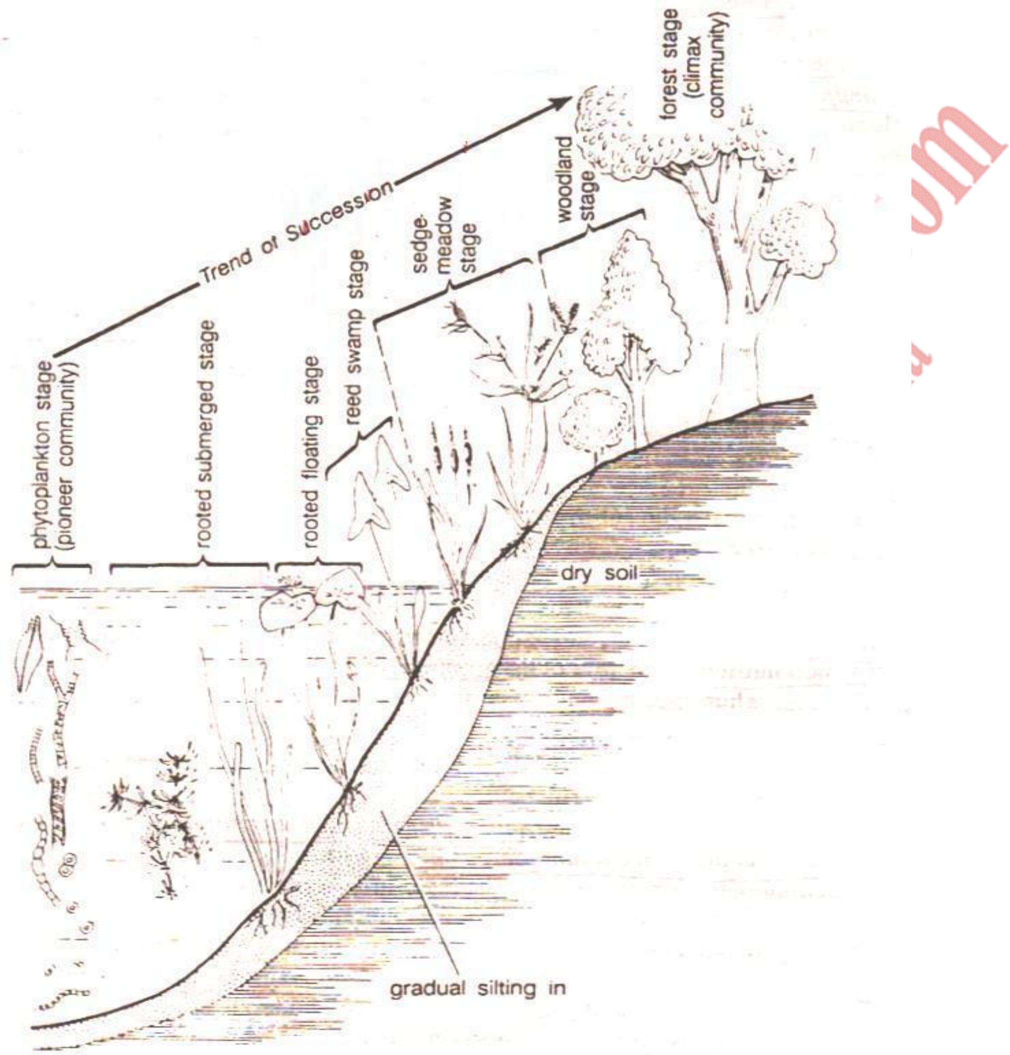


Diagram showing different plant communities appearing at different stages of a hydrosere originating in a pond. Note the gradual decrease in water level and successive development of the soil in area to give finally a terrestrial habitat for forest climax community.

(4) Reed-Swamp stage:

This stage is known as amphibious stage as the plants of community are rooted but most parts of their shoots (assimilatory organs) remain exposed to air.
Species of Typha, Scirpus, Sagittaria and Phragmites etc. are the chief plants of this stage.
They have well developed rhizomes and form a very dense vegetation. The water level is by now very much reduced and finally becomes unsuitable for the growth of these amphibious species.

(5) Sedge-meadow stage:

Due to successive decrease in water level and further changes in the substratum, species of some Cyperaceae and Gramineae such as Carex, Juncus, Cyperus and Eleocharis colonize the area.
They form a mat-like vegetation towards the centre of the pond with the help of their much branched rhizomatous systems. As a result of high rate of transpiration, there is much rapid loss of water and sooner or later the mud is exposed to air as a result of which nutrients like ammonia, sulphides etc. become oxidized to nitrates and sulphates. Thus, mesic conditions approach the area and marshy vegetation disappears gradually and gradually.

(6) Woodland stage:

By the time of disappearance of marshy vegetation, soil becomes drier for most time of the year. This area is now invaded by terrestrial plants, which are some shrubs (Salix, Cornus) and trees (Populus, Almces). There is much accumulation of humus with rich flora of microorganisms. Thus, mineralization of the soil favours the arrival of new tree species in the area.

(7) Forest stage:

This is the climax community. The woodland community is rapidly invaded by several trees. In tropical climates, with heavy rainfall, there develop tropical rain forests, whereas in temperate regions, there develop mixed forests of Almus, Acer and Quercus. In regions of moderate rainfall, there develop tropical deciduous forests or monsoon forests.

Successive changes in animal life during Hydrosere:

The Protozoan's like Paramecium, Amoeba, Euglena etc. are the pioneers, but if the planktonic growth forms are very rich, other animal life as blue gill fish, sun fish, largemouth bass etc, start appearing. Some caddisflies are also found.
In the next, submerged stage, the caddisflies are replaced by other animals that may creep over the submerged vegetation. Thus, dragon flies, mayflies' and some crustaceans as Daphnia, Cypris, Cyclops, Gammarus etc inhabit the pond at this stage.
At the floating stage, the animal life is chiefly represented by Hydra spp. Gill breathing snails, frogs, salamanders, diving beetles, whirligig beetles and other insects. There also appear some turtles and snakes.
At the reed-swamp stage, the pond becomes shallower and the bottom starts becoming exposed. The floating animals are replaced by different species of mayflies and dragon flies, whose nymphs remain, attached to submerged parts of the vegetation, and adults present on the surfaces of emergent plants.
Gill breathing snails are replaced by lung breathers as Lymnea , Physa, and Gyraulus.
Among insects, water scorpion, giant water bug, scavenger bettles etc. are present at this stage. The bottom of the pond is now inhabited by some annelids, mud pickrel and bull heads. Red winged black birds, king fisher, great blue heron, swamp sparrow, ducks, musk rats, beavers etc become common in the area.
At the sedge meadow stage, the animals like snails as Anodonta, Psidium etc become common. Finally, at the woodland stage under terrestrial conditions most of the terrestrial forms of animal life appear in the area.

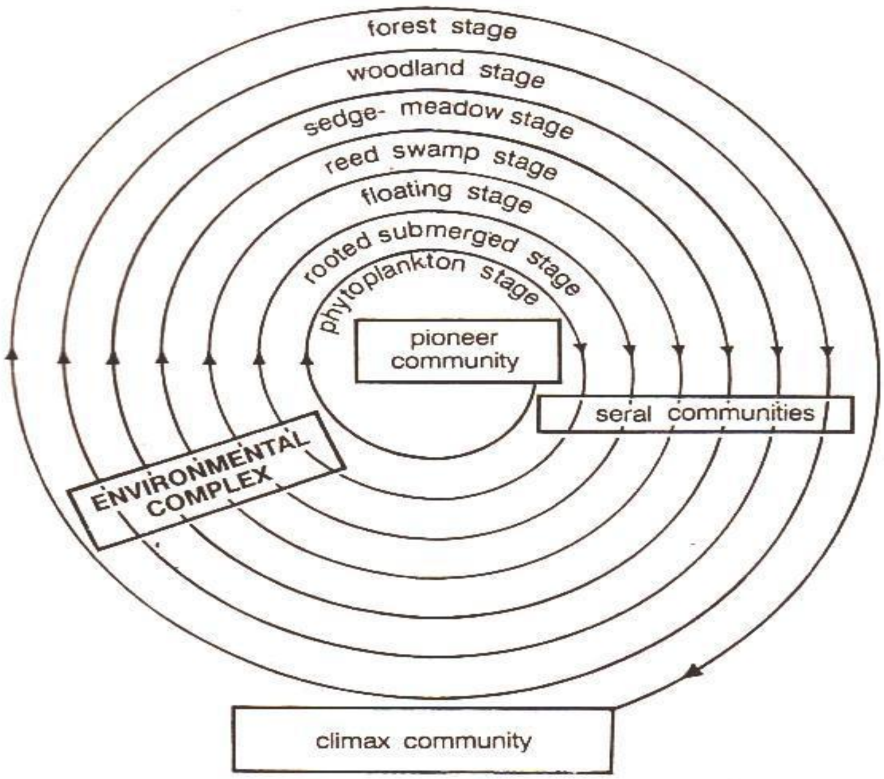


Diagram to show general process of succession with different plant communities appearing therein under the influence of developing environ-mental complex, taking hydrosere as an example. Note the pioneer, seral and climax communities.

Q-2 Define population? Describe the various characteristics of a population.

Ans. Population:

A population is generally a group of individuals, of a particular species occupying a particular area at a specific time. Some of the ecologists however recognize two types of population.

(1) Monospecific population:

It is the population of individuals of only one species and

(2) Mixed or polyspecific population:

It is the population of individuals of more than one species. However, in ecology polyspecific population is generally referred to as a community and the term population is used for group of individuals of any kind of organism.

Population Characteristics:

The characteristics of population are as follows-

(I) Population size and Density:-

Total size is generally expressed as the no. of individuals in a population. More informative are the estimates of density, the number per unit area (or volume) of environment. Larger organisms as trees may be expressed as 500 trees per hectare, whereas smaller ones like phytoplanktons (as algae) as 2 million cells per cubic meter of water.

(1) Crude density: It is the density (number or biomass) per unit total space.

(2) Specific or ecological or economic density:

It is the density (number or biomass) per unit of habitat space i.e. available area or volume that can actually be colonized by the population.

The population is growing and changing entity, and a record of its density at daily , weekly or monthly interval gives its dynamics. If we divide the change in any measured parameter by the time elapsed during which the change has taken place, then we get the rate.

e.g. if the no. of individuals of a species in a given area increases from 50 to 100 in 10 days, then the population growth rate will be 100-50/10 = 5 per day.

(II) **Dispersion:**

It is the spatial pattern of individuals in a population relative to one another.

(1) Regular dispersion:

Here the position of one individual is unrelated to the positions of its neighbors.

(2) Clumped dispersion:

Most populations' exhibit this dispersion to some extent, with individual's aggregated into patches interspersed with no or few individuals; such aggregations may result from social aggregations such as family groups.

(3) Regular dispersion:

Here the individuals are more or less spaced at equal distance from one another. This is rare in nature, but is common in managed systems (cropland). Animals with territorial behavior tend towards this dispersion.

(4) Age structure:-

In most populations, individuals are of different ages. The proportion of individuals in each age group is called age structure of that population e.g. for instance an understory palm tree population (Astrocafum mexicanum) in an evergreen forest of Mexico, had 50% individuals as seedlings (less than 2 year-old) 19% as saplings (8- year old), 5% as 30- year old adults and 70- year old trees made up of less than 2% of the population.

Age distribution is important, as it influences both natality, and mortality of the population. There are three major ecological races (age groups) in any population. These are pre -reproductive. Reproductive and post -reproductive.

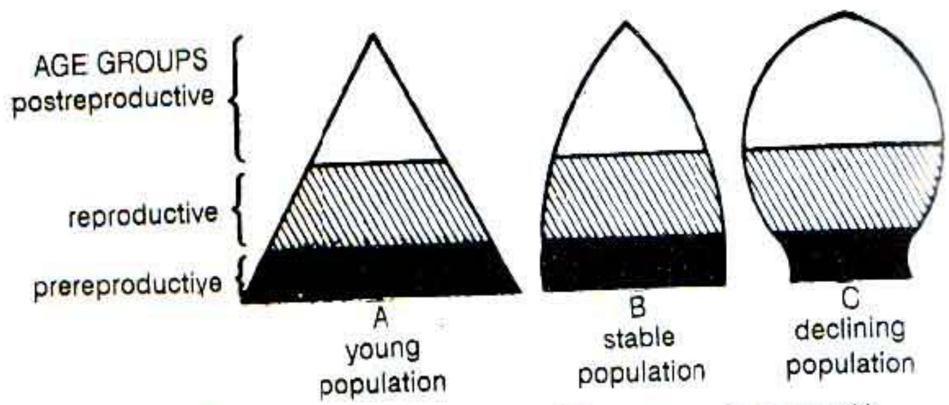


Fig. 4. Hypothetical diagram showing different types of age pyramids.

Age pyramids:

The model representing geometrically the proportions of different age groups in the population of any organism is called age pyramid. There are three hypothetical pyramid types:

(a) A pyramid with broad base:

It indicates a high percentage of young individuals. In rapidly growing young populations, birth rate is high and population growth may be exponential as in yeast , house fly, paramecium etc. Under such conditions each successive generation will be more numerous than the preceding one, and thus a pyramid with broad base would result.

(b) A bell-shaped polygon:

It indicates a moderate proportion of young to old. As the rate of growth becomes slow and stable, i.e. the pre-reproductive and reproductive age groups become more or less equal in size, post -reproductive groups remaining as the smallest, there results a bell-shaped structure.

(c) **An urn-shaped figure:**

It indicates a low percentage of young individuals. If the birth rate is drastically reduced, the pre -reproductive group dwindles in proportion to the other two groups and it results in an urn-shaped figure, which indicates that population is dying off.

(IV) Natality: (birth rate):-

Natality rate is the number of offsprings produced per female per unit time. These are distinguished into two types of natality.

(1) Maximum (absolute or potential or physiological) natality:

It is the theoretical maximum production of new individuals under ideal conditions (i.e. no ecological limiting factors, reproduction is limited only by physiological factors). It is constant for a given population. This is also called fecundity rate.

(2) Ecological or relaised natality:-

It is also known as natality. It refers to population increase under an actual, existing specific condition. Thus it takes into account all possible existing environmental conditions. This is also designated as fertility rate.

Natality is expressed as

$\Delta N_n/\Delta t$ = the absolute natality rate (B)

$\Delta N_n/N\Delta t$ = the specific natality rate (natality rate per unit of population)

Where N = initial number of organisms

n = new individuals in the population

t = time

(V) **Mortality (death rate):**

It refers to death of individuals in the population. Mortality may be-

(1) Minimum mortality:

Also called specific or potential mortality. It represents the theoretical minimum loss under ideal or non-limiting conditions. It is a constant for a population.

(2) Ecological or realized mortality:

It is the actual loss of individuals under a given environmental condition. Mortality can be expressed as the no. of individuals dying in a given period (deaths per time) or as specific rate in terms of units of the total population.

A birth-death ratio $\left(100 \times \frac{\text{births}}{\text{deaths}}\right)$ is called vital index.

But survival rates are of much interest than the death rates.

Survival rates are expressed by survivorship curves

(a) **Highly convex curves:**

It (curve A) is characteristic of the species in which the population mortality rate is low until near the end of the life span. Thus, such species tend to live throughout their life span, with low mortality. Many species of large animals as deer, mountain sheep and men etc. show such curves.

(b) **Highly concave curve:**

This curve (curve C) is characteristic of such species where mortality rate is high during the young stages e.g. Oysters, or other shell fish, oak trees etc.

(c) **Diagonal curves:**

If age-specific survival is more nearly constant, the curve approaches a diagonal straight line (curve B2) .Thus it shows a constant proportion of organisms dying per unit time.

A slightly concave or sigmoid curve (B3 in figure) is characteristic of many birds, mice and rabbits. In these cases, the mortality rate is high in the young but lower and more nearly constant in the adult (1 year or older)

In some halometabolous insects (insects with complete metamorphosis), such as butterflies, there is expected, generally a 'stair step' type of curve (B_1 in the figure).

Q-3 Discuss in detail the methods of study of communities.

Ans. **Community:**

A group of several species (plants and/or animals) living together with mutual tolerance (adjustment) and beneficial interactions in a natural area is known as a community. A forest, grassland, as desert or a pond are natural communities.

Various methods of study of plant communities are broadly grouped into three major categories-

(1) Floristic methods:

Here the flora is studied by listing various genera and species present in the community. Thus, vegetation is described in terms of the flora.

(I) Physiognomic methods:

The various species of the community are studied chiefly in terms of their life-forms (growth forms), general stature, spread etc.

Raunkiaer's Life form method:

This method has two parts-

(a) Record of different life forms:- i.e. phanerophytes, chamaeophytes hemicryptophytes, cryptophytes and therophytes, on the basis of the position of renewal bud or organs in the species.

(i) <u>Phanerophytes</u>:

Their buds are naked or covered with scales, and are situated high up on the plant. These life forms include trees, shrubs and climbers generally found in tropical climates.

(a) Megaphanerophytes (over 30 meters high)

(b) Mesophanerophytes (8 – 30 meters high)

(c) Micro-phanerophytes (2 – 8 meters high) and

(d) Nano-phanerophytes (under 2 meters)

(ii) **<u>Chamaephytes</u>**:

Their buds are situated close to the ground surface. They are common at high altitudes, e.g. Trifolium repens.

(iii) <u>Hemicryptophytes</u>:

These are mostly found in cold temperate zone. Their buds are hidden under soil surface, protected by the soil itself. Their shoots generally die each year e.g. most of the biennial and perennial herbs.

(IV) **<u>Cryptophytes or Geophytes</u>:**

Their buds are completely hidden in the soil, as bulbs and rhizomes. Most of them are found in arid zones. Hydrophytes are the cryptophytes whose buds are formed below the water surface.

(V) **<u>Therophytes:</u>**

These are seasonal plants, completing their life cycle in a single favorable season, and remain dormant throughout the rest unfavorable period of year in the form of seeds. They are common in deserts.

(b) <u>Biological (Phyto-climatic) spectrum</u>:

Biological spectrum represents the percentage (% of the total species in the community) distribution of species among the various life forms. Thus through calculation of percentage value of each life-form, biological spectrum of the area is obtained.

(II) <u>Phytosociological methods:</u>

Methods, based upon some characteristics - phytosociological methods were developed simultaneously in U.S.A. , Britain, and Southern and Northern Europe.

<u>Sampling units</u>:

In phytosociological methods, which are many there are generally three forms of sampling units: area, line and point.

On the basis of the nature of the sampling units, there are three popular methods of study of communities-

(1) <u>Quadrat method</u>:

Sampling unit is a quadrat, which is an area of a definite size. In shape, it may be square, rectangle or a circle. Depending upon the type of vegetation and purpose of study, a quadrat may be.

(a) <u>List quadrat:</u>

The species present in the area are simply listed.

(b) <u>List-count quadrat</u>:

Besides listing the various species, numerical counts of individuals of each species are also made.

(c) <u>Chart quadrat:</u>

Here a detailed to-scale growth and distribution of each species in space is recorded. The individuals are recorded on a miniature quadrat on graph paper by the use of pantograph at intervals of months or years.

(d) <u>Experimental permanent quadrat</u>:

The chart quadrat is left undisturbed and the area is studied for vegetational changes over a long period, to study periodic changes in community.

Study of community by quadrat method involves three steps-

(i) To determine the minimum size of quadrat by species-Area-curve method.

(ii) To determine the minimum number of quadrats to be laid down and

(iii) Record of the species: - Their listing, and counting of the individuals of each species.

After the record of various species, the value of frequency, density, abundance are determined for each species of the community.

After determining the frequency (%) of each species, these are then distributed among Raunkiaer's five frequency classes – A, B, C, D, E depending upon their frequency (%) values as follows:-

Frequency 1% Frequency class

0 – 20	A
21 - 40	B
41 - 60	C
61 – 80	D
81 – 100	E

Now find out the values (as % of the total species) of each of the five frequency classes to prepare the frequency diagram.

(2) **Transect method:**

A transect is a sampling strip extending across a stand or several stands of vegetation where line is the sampling unit. It may be:

(a) Line-transect:-

Line-transect is a thin line, which is generally used for grasslands or

(b) Belt transect:-

Belt transect is a belt of suitable breadth, used for forests. The transect is divided into segments of suitable length. This method is useful to analyze the vegetation changing in its composition through an ecotone. Each segment may be taken as a quadrat.

(3) **Point method:-**

The sampling unit is a point. A number of movable pins (usually 10, about 50 cm long) are inserted in a wooden frame, known as point frame. The pins are laid down at random in the area. Plants hit by pins are recorded. Thus frequency (1%) of each species is calculated. One hit of pin taken by a species is taken as its occurrence in the sampling unit. For density values, there are two alternative procedures-

(i) Random pair method and

(ii) Point centered quarter method

UNIT-IV

Plant Cultivation

Q-1 Describe about the botanical characteristics of wheat.

Ans

Botanical Characteristics

The wheat stem (culm) is erect and cylindrical (0.6-1.5 m in height), the nodes are solid whereas the internodes are hollow.

There are two sets of roots, 3-6 seminal or seedling roots developing from the embryo and the adventitious roots (coronal), arising later from the basal underground nodes of the axis, representing the permanent root system. Secondary shoots or tillers arise from the axillary buds present on the underground portion of the stem and bear a similar series of coronal roots.

Each leaf consists of four parts

(1) The blade or lamina which is narrowly linear to linear lanceolate, about 20-37 cm long and nearly 1-2 cm wide.

(2) The leaf sheath which encircles the stem tightly.

(3) A membranous ligule with margins fringed by hairs (also known as rain-guard) growing at the junction of the blade and the leaf sheath and,

(4) The auricles which are two claw-like appendages at the base of the blade.

The wheat inflorescence is a terminal distichous spike i.e. with spikelets borne singly at the nodes on alternate sides of the zig-zag rachis. Each spikelet consists of two to five florets attached alternately on opposite sides of a short central axis called the 'rachilla' and is subtended by two sterile or empty glumes. Each floret has its own lemma and a thin two nerved palea in vesting the essential organs (three stamens and single pistil with two feathery stigmas) and two lodicules representing the perianth - a structure that regulates the opening of the flower. The lamellar midrib is often extended in the form of an awn. Depending on its presence the spikes are referred to as awned (bearded) or awnless (beardless).

The wheat grain is a dry, one seeded, indehiscent fruit, known as a caryopsis. The grain may be either hard or soft in texture with a creamy white amber, red or purple colour depending upon the variety. The dorsal convex surface of the kernel is smooth save for the base where the fruit coat is wrinkled, indicating the position of the embryo.

The ventral surface is flat and is characterized by a deep furrow or groove (crease). The tip of the grain has a type of persistent stiff hairs known as the 'brush'

The following four structures are recognizable in the wheat grain, the grain coats, the nucellar epidermis, the endosperm and the embryo.

The tissues of the pericarp form a thin protective covering and consist of several layers: epidermis, hypodermis, remnants of thin walled cells. Intermediate cells, cross cells and tube cells. The seed coat or testa is firmly fused with the innermost cells of the pericarp i.e. cross and tube cells on the outside and the nucellar epidermis on the inside. The nucellar layer is composed of a single row of compressed cells between the testa and the endosperm.

The endosperm makes up about 82 percent of the grain by weight. The delimiting layer of the endosperm, the aleurone layer ,is rich in nutrients, particularly niacin, vitamins of the B group and minerals. It has high protein content but is devoid of gluten and starch. The remaining portion of the endosperm is chiefly composed of starch.

The embryonic axis consists of the plumule surrounded by a sheath known as the coleoptile and the primary root or radical, enclosed by the coleorhiza or root sheath.

Attached to the embryonic axis, nearest to the endosperm is a fleshy shield – like structure, the cotyledon or scutellum. It forms the greater portion of the embryo, opposite the scutellum, there is small scale-like growth known as epiblast.

A well-developed kernel contains about nine to ten percent bran coat (pericarp, testa and nucellar layer), 2.5 percent germ or embryo, 85-86 percent starchy endosperm and 3-4 percent aleurone.

Cultivation of wheat

Wheat is the world's most widely cultivated plant. Every month of the year, a crop of wheat is maturing somewhere in the world.

Wheat can be grown on a wide range of soils but is best adapted to fertile silt and clay loams, (with pH not less than 5.8) with good drainage and water holding capacity. Very sandy or poorly drained soils are not good for wheat cultivation.

Wheat cultivation extends from the plains to about 3000 m above sea level. The crop is irrigated in Punjab, Haryana, parts of Uttar Pradesh, Maharashtra, Rajasthan and Madhya Pradesh, in Bihar, eastern Uttar Pradesh, West Bengal and in hilly areas. It is generally raised as a rainfed or barani crop. In hilly areas, the crop is grown on terraced fields cut across the steep slopes.

Wheat is typically a winter crop in India, sown in September or October after the summer monsoon rains are over. The water conserved during heavy monsoons is beneficial for wheat cultivation in the succeeding rabi season as this part of the year is relatively dry, except for occasional showers in some parts. If the winter rains are good and well distributed, they supplement the stored soil moisture and lead to a good crop.

The cultivation of wheat varies from primitive methods, still practiced in a few areas of the world to complete mechanization of the entire operation from soil preparation to harvesting and processing etc.

Wheat is grown in rotation with other crops such as cotton, maize, mung bean, pearl millet, sorghum, sugarcane or tobacco; the latter particularly reduces weeds. Mixed cropping of wheat with gram and mustard in North India and with gram or linseed in the black cotton soils is commonly practiced.

Wheat requires a well pulverized, but compact soil for good and uniform germination. On the barani or non-irrigated land, the soil may be ploughed with a non-inversion or 'desi' plough as many as 20 times but 8 to 10 ploughings are quite common. Under irrigated conditions, the land should be initially ploughed with a soil inversion plough and this is usually followed by four or five ploughings with a 'desi' plough.

Before sowing, land is brought to a fairly fine tilth and leveled with a leveling plank or suhaga. Seeds can be sown by broadcasting, drilling or dibbling, but seeds drills are more commonly employed. Deep sowing is advisable in rough, dry and light soils and shallower sowing in moist or heavy land. Under irrigated conditions, the land is immediately leveled after sowing, while in the barani condition leveling after seeding is not carried out.

The water requirements are quite different for the traditional tall and modern dwarf wheat's. If the monsoon rains are normal, the tall varieties should be given two irrigations during the crop season.

The first should be applied four to six weeks after sowing, while the second should be given at the heading stage or at the bloom stage, preferably on a windless day as the crop is likely to lodge. In contrast, the dwarf wheat need four irrigations, the first at the time of crown root initiation, usually between three and four weeks after sowing. Three additional irrigations on loam and heavy soils should be applied at the late tillering, flowering and dough stage; the last one should be given on calm or windless day as the crop is top heavy. Two or more extra irrigations may be needed in the case of sandy soils.

Wheat responds well to the application of commercial fertilizers. Nitrogenous fertilizers are used in small quantities in conjunction with phosphorus and potassium.

Under non-irrigated conditions, fertilizers are applied just before seeding, while on the irrigated crop half is applied before sowing and the remainder is top dressed with the first irrigation.

Q-2 Describe the origin, distribution and tapping of rubber.

Ans. <u>Tapping of rubber</u>:

Rubber collectors of the Amazon valley, known as 'seringueros' originally gathered latex by cutting down the wild trees of Hevea but latter tapped them by making haphazard wounds with the help of crude, heavy hand axes or hatchets (the machadino method). Although care was taken not to injure the growth layer damage was not uncommon. Such ruthless tapping not only disfigured the trees best also made them vulnerable to insect attack and wood rot.

Depending upon the type and extent of the cuts, three different methods of tapping are recognized: V-cut system , herring bone system and spiral panel system, also known as Jebong system.

(i) In the V-cut system, two slanting incisions are made like the two arms of V and at the bottom of their junction, metallic spouts made either of zinc or iron are inserted to conduct the latex into the receiving cup.
(ii) In the herring bone system, a number of oblique cuts, all converging to a vertical line, are made into the bark. These tapping cuts may be on both sides of the line, or only on one side. The latex runs down the cuts into the central one which conducts it to the cup placed at the bottom.
(iii) In the spiral panel system, a typical cut at an angle of 30-35ºC is made from the upper left to the lower right, half way around the tree. (Half spiral panel) or completely around the circumference of the trunk (full spiral panel).
(iv) A specially designed Jebong's knife of high quality steel is used. The knife has a V-shaped head which can be adjusted to cut the proper thickness of bark (about 1 mm). Thus, the latex vessels are severed transversely.

Tapping is invariably started in the early hours of the morning when the flow of latex is copious owing to high turgor pressure. It slackens as the time passes by and finally stops at midday. Latex runs down the channel of the cut to a spout and into a small receptacle to which a few drops of an anticoagulant such as ammonia, formaldehyde or sodium hydroxide are added. The yield of latex can be increased, sometimes as much as 30 percent, by the application of growth hormones such as 2, 4-D and 2, 4, 5-T just below the tapping cut. During each tapping, coagulated latex on the cut is removed by hand and kept separate as 'scrap' which on processing yields rubber of inferior grade.

The trees are tapped every other day but often rested after heavy tapping, during foliage drop or rain. Each subsequent cut is made immediately below the previous one. After the tapping has reached ground level on one side, the opposite side is worked. If the early tappings are carefully done, new bark regenerates in the region of the tapped panel because of the meristematic activity of the underlying cambium and is ready for tapping again.

Lower panels give more yield than high panels. Tapping is generally started at 2 m or more above the ground and about 15 cm of the trunk bark is tapped during a year. In this way, it normally takes 10-12 years to work on one side, and thereafter the other side is tapped.

A recent improvement in the taping system is to make incisions upwards on the panel rather than downwards. To maintain a high quality of rubber products, scrupulous cleanliness is observed from the tapping stage until the latex reaches the processing unit.

The rubber is shipped either as concentrated liquid latex or in a solid form. To prepare solid rubber the strained and diluted latex is transferred to large aluminum tanks to which acetic or formic acid is added (2 kg of acetic acid or 1 kg of formic acid to 400 kg of rubber latex). As a result of this treatment, the tiny rubber particles dispersed throughout the latex clump together on the top as soft, white spongy mass. Certain chemicals may be added to prevent fungal growth and to lighten the color of the finished product. This soft coagulum or slab, after washing, is passed through a succession of rollers to squeeze out the excess water and also to flatten it to a desirable thickness (about 3.0 mm) and air dried, thus producing sheets of 'crepe rubber'.

Quite often, the sheets are smoked by exposing them to the pyroligneous acid vapors from burning wood. The smoked product is known as 'sheet rubber'. Smoked sheets are translucent, amber or brown colored, elastic and durable. Most of the rubber is exported in this form. The dried rubber must be broken down in a rubber mill (milled) before chemicals can be mixed.

A recent innovative approach is to ship raw rubber in a compressed granular form ('heveacrumb') rather than as a smoked sheet. Many methods have been devised to produce it but the Pulvatex (stam) and Mealorub processes are most commonly used.

Q-3 Write essay on the origin, botanical characters, cultivation and improved varieties of maize.

Ans. **<u>Botanical Characters</u>:**

Maize is a fast growing, erect usually single-stemmed, succulent annual grass (about 1-5 m tall), forming very few tillers. The root system consists of seminal, coronal or crown and brace, buttress or aerial roots.

The seminal roots consist of the radical (primary seminal root) plus three or more secondary seminal roots that grow out sideways from the embryo. They quickly lose their importance and the young plant is nourished and supported by the main fibrous root system (coronal) developing from the lower nodes of the stem below ground level.

Brace or prop roots make their appearance soon after tasseling and arise from the nodes just above the soil surface. They are thick and partially photosynthetic, but on entering the soil they branch and behave like coronal roots.

The internodes in the basal region of the plants are short and fairly thick, becoming progressively longer and thicker higher up the stem. Them they taper and finally terminate in the male inflorescence.

The leaves are distichous. The leaf consists of the leaf sheath, and the lamina, with membranous ligule at the junction of two. The leaf blade is linear- lanceolate, acuminate, wavy, 50 to 70 cm in length and 8 to 19 cm wide at its broadest point, usually with hairs along the upper margins

The maize plant is monoecious and diclinous (male and female inflorescence borne separately on the same plant).

The male inflorescence is commonly referred to as the tassel occupying the terminal position on the main axis.

The female inflorescence 'cob' or 'ear' is also borne terminally but on a modified lateral branch developing from the axillary bud of the main stem.

The male inflorescence is a compact, much branched panicle; the branches are spirally arranged around the main axis. Paired spikelets are carried in several rows on the main axis and in two rows on the lateral branches.

Each spikelet consists of a pair of glumes that invest two florets, each of which is enclosed by a lemma and palea and has two lodicules, three stamens and a rudimentary pistil.

The greatly enlarged and overlapping leaf-sheaths, arising from each node, form a protective covering 'husk' or 'shucks' around the terminal inflorescence. The pistillate inflorescence or ear itself is a spike, with thickened axis , on which are borne paired spikelets in several longitudinal rows, the number of which may vary from 2 to 36, but the usual number is 16, 18 or 20 in hybrid dent maize.

Each paired spikelet is associated with a socket or 'cupules'. The cupules of one row alternate with those of another row. Both the spikelets are sessile and identical.

Each spikelet is two flowered, having a pair of small membranous glumes. The lower flower is non-functional, represented by a lemma and a palea.

The upper one is fertile and consists of a membranous lemma and palea (collectively constituting the chaff) rudimentary stamens and a knob shaped ovary surmounted by a long thread-like style 'the silk' which grows rapidly and emerges from the top of the husk. The silk from the base of the cob appears first and those from the tip come out last. The styles are generally receptive all along their length and at the tip are usually cleft into two short unequal branches, the stigmas.

Botanically, a corn kernel is a caryopsis – a dry, one-seeded indehiscent fruit where the pericarp is fused with the seed coat forming a tough protective covering.

The rachis of maize does not disarticulate at maturity and has no mechanism for seed dispersal. The mature kernel is made up of four major parts: the tip cap, the pericarp and the seed coat together known as the 'hull' , the endosperm and the embryo or germ.

The tip cap consists of the remnants of the tissue where the kernel is joined to the cob. At maturity, the spongy cells of the tip cap, at the point of attachment to the germ, form a black tissue – the hilar layer which serves as a sealing mechanism.

The hull is composed of several layers of pericarp cells. The integuments or seed coats are represented by non-cellular remnants. A silk scar is present on the pericarp at the apical end of the grain.

The endosperm constitutes the main bulk of the kernel. The outer most layer of the endosperm just underneath the nucellar epidermis is the aleurone layer where most of the stored proteins are deposited. The greater part of the endosperm consists of large cells packed with starch grains.

The maize endosperm is of two types: hard, flinty endosperm, opalescent in appearance, and containing a higher proportion of protein than the other starchy type which is white and floury in appearance and of much softer texture.

The color of these two kinds of endosperm also differs greatly with a variety, ranging from white through yellow, red and purple to almost black (Cobley, 1956).

The embryo occupies a small area of the kernel, lying at the base and in close contact with one of the faces of the endosperm. It consists of the plumule, radical and scutellum. The plumule and radical are each enclosed by a sheath known as the coleoptiles and coleorhizae respectively. The scutellum or cotyledon is an oval, shield-shaped structure. The embryo is relatively rich in fats (about 6 percent). minerals, proteins and sugars. The high percentage of fats in the maize kernel in comparison with other cereals makes it suitable for oil extraction.

Cultivation of Maize:

Maize is a rich land crop and can be grown in a wide variety of climates and on a very diverse kinds of soil as is evident from its wide geographical distribution, extending from latitude 58ºN in Canada and the CIS to latitude 40ºS in the Southern Hemisphere, with a maize crop maturing somewhere in the world every month of the year. The bulk of the crop is grown in the warmer parts of the temperate regions and in the humid sub tropics.

For optimum production, maize requires the following essentials: a fertile, well drained loam soil, a generous well distributed rainfall. A frost free growing season of 110-130 days and a moderately high temperature

Maize is grown on a wide variety of soils ranging from fairly coarse sand to the heaviest of clays. It grows best on fertile, friable, well-drained warm loam and salty loam soils, well supplied with organic matter and available nutrients. . Maize can be grown under a wide range of soil reactions, but the optimum pH range is from 5 to 7.

Being a water-loving crop, maize demands a constant supply of moisture throughout the growing period. Little maize is produced in areas where the annual rainfall averages less than 50-65 cm. The demand for water is greatest during the silking and tasseling stage. Acute moisture shortage during this period will produce poorly filled ears. Maize is a sun-loving crop and requires a long, hot growing season with plenty of sunshine. It is best adapted to regions where both day and night temperatures are over 21ºC during much of the growing period. Cool nights, retard growth and delay maturation. The crop cannot tolerate frost.

The maize plant is a heavy feeder, requiring an intelligent fertilizer programme. It required a lot of nitrogen, potash, phosphorus, calcium and magnesium for a maximum yield.

Q -4 Write in detail about economic botany of Cinchona and Rauwolfia.

Ans. Cinchona:

The anti-malarial property of Cinchona bark was known to the South American Indians from early times. Many stories are told regarding the discovery of Cinchona, revolving round the countess of Chinchon, wife of the Viceroy of Peru, who was supposedly cured of malaria in 1638, after all other cures had failed.
It is also learnt that the secret of the efficacy of this bark was revealed by a native maid out of affection for his mistress. The countess was so pleased with the efficacy of the drug that she introduced it into Europe in 1640.
In the eighteenth century, Linnaeus named it Cinchona in honour of this gracious lady.
Cinchona spp. are evergreen shrubs or trees with opposite, simple entire leaves and interpetiolar stipules. Small fragrant flowers are borne on terminal panicles. The capsular fruits are oblong to ovoid-lanceolate. The plants are found growing at altitudes ranging from 760 to 2750 (seldom below 300 m).
Plants prefer cool Mountain slopes with an abundant and well-distributed rainfall of over 220 cm. The plants grow best on light, well drained, virgin forest soils rich in organic matter, with a pH of 4.5 - 6.5. Propagation is either by seeds or by vegetative means. i.e. grafting and cuttings.
At present, Cinchona is cultivated on a large scale in India and Indonesia. A limited supply is also obtained from Tanzania, Sri Lanka and Myanmar.
The bark of Cinchona roots contains the highest concentration of total alkaloids, but the bark of the trunk is the richest source of quinine.
Nearly, 30 alkaloids have been isolated from Cinchona spp. Of which the most important are-
Quinine, quinidine, Cinchonine and its isomer Cinchonidine - all four collectively known as 'totaquine' & other less important alkaloids are Cinchotine, javanine, hydroquinine, hydroquinidine, cusconidine , cuscamine and cuscamidine.
In addition to its use for the treatment of malarial fevers, it is also valuable as a tonic and an antiseptic. Quinine, Quinidine, and their compounds are employed in insecticides for the preservation of fur, feathers, wool, felt and textiles. The residual bark of Cinchona, left after the extraction of alkaloids, is used as a tanning material. The alkaloid quinidine is a cardiac depressant.
Several species of Remijia (family Rubiaceae) particularly R. purdieana Wedd . and R. pedunculata Flueck, are promising substitutes for Cinchona and contain substantial amounts of quinine and quinidine in the bark. Besides these, roots, stem and leaves of Chamaebatia foliolosa Benth. (Rosaceae) are also sources of these alkaloids.

Rauvolfia serpentina ex. Kurz.:

Rauwolfia

Family: **Apocynaceae**

The dried roots of Rauvolfia serpentina are used by the people of India as a cure for epilepsy, high blood pressure, insanity, intestinal disorders, cardiac diseases, snakebite and as an antihelmintic.
Some of the active alkaloidal constituents e.g. ajmaline, ajmalinine, ajmalicine, serpentine and serpentinine were isolated for the first time by the Indian chemists Siddiqui and Siddiqui in 1931.
Indian Rauwolfias have now assumed a leading position in modern medicine especially since the isolation of the main alkaloidal constituent, reserpine by Muller, Schlittler and Bein of the CIBA Laboratories, Switzerland in 1952.
Resperpine was the first tranquiliser to be used for the treatment of schizophrenia and other forms of mental disorders. Being a hypotensive agent, reserpine is widely employed today for hypertension ((high blood pressure).
The drug rauwolfia is derived from the roots (especially the bark) of different species of Rauwolfia, named in honour of Leonhard Rauwolf, a German physician of the sixteenth century. Five species have been recorded in India of which R. serpentine has attained a great reputation as medicinal plant.
R. serpentine is an upright, perennating, evergreen glabrous under shrub with tuberous roots with a characteristic slightly wrinkled and coarse surface. The root bark is greyish yellow to brown and displays irregular longitudinal fissures.
The leaves are simple. glabrous, lanceolate or obovate and are generally in whorls of three to four, crowding the upper part of the stem. The inflorescence is generally, terminal but sometimes axillary, and usually consists of dense crowded cymes.
R. serpentina grows wild in India, Bangladesh, Sri Lanka Myanmar, Thailand, Indonesia and Malaysia, The plant is found in almost all parts of India from Kerala to the Himalayan foothills, except Rajasthan province. It is widely distributed in the sub-Himalayan tract (up to an elevation of about 1000 m) and in the lower ranges of the eastern and western ghats and in the Andaman's.
The plant grows in tropical or subtropical regions, benefiting from the monsoon rains. It may be grown almost anywhere at low or medium elevations where rainfall is not less than 75 cm.
Rauwolfias flourish in hot humid conditions and can be grown both in the open and in partial shade. Soils with plenty of humus and a pH 4.0 – 6.3 are desirable for good growth. The plants are best raised from root-cuttings, but seeds and stem cuttings can also be used for propagation.
It has been estimated that the alkaloid content of the roots harvested after the shedding of leaves in far richer than roots dug out in August.

The total alkaloid content of the root varies from 1.7 - 3.0 percent, of which the bark alone accounts for nearly 90 percent.

A large number of alkaloids (80 or more) have been isolated from various species of Rauwolfia. Reserpine is pharmacologically the most potent. Other important alkaloids are reserpinine, deserpidine, serpentine, serpentinine, ajmaline,ajmalinine, isoajmaline, rauwolfinine and yohimbine.

Reserpine stimulates uterine contraction and is recommended for use in child birth. An extract of the leaves has also been employed as a cure for the opacity of the cornea.

Q-4 Write short notes on Vavilov's concept or Describe Vavilov's concept.

Ans. **<u>The work of Vavilov</u>:**

Vavilov deductions are based on a variety of facts, obtained from sources different from those of his predecessors, such as morphology, anatomy, cytology, genetics, distribution and reaction to diseases.

Vavilov made an inventory of the diverse forms of our most important cultivated plants and most distribution over the various parts of the earth. He observed that the distribution of plant species is not uniform. In some restricted areas, a wide range of genetic variability is encountered e.g. Ethiopia for what and South America for potato.

There are few such regions and generally they are small areas confined to the mountains or foothills of the tropics and subtropics. Vavilov calls these regions with the greatest wealth of forms, gene or diversity centers and suggested that these are regions of origin as well as dispersal. At first, Vavilov suggested six main geographic centers for cultivated plants but subsequently increased their number to 11. The main world centers of diversity as recognized and mapped by Vavilov and his associates are listed below.

World centers of origin of cultivated plants (after Vavilov)

(I) **<u>Chinese centre</u>**

This is the earliest and largest independent centre for the origin of cultivated plants. It includes the mountainous regions of central and Western China and the adjacent lowlands. A total of 136 endemic plants are listed among which are a few important, crops such as millet, soyabean, many legumes, bamboo, crucifers, onion, lettuce, eggplant. Cucurbits, pear, cherry, citrus, sugarcane, cinnamon and tea.

(II) <u>Indian Centre</u>:

(A) The main centre includes Assam and Burma (now called Myanmar). One hundred and seventeen plants are considered to be endemic, including rice, sugarcane, many legumes, mango, orange and tangerine, jute, coconut palm, oriental cotton, black pepper, cinnamon tree, eggplant, yam etc.

(B) **The Indo-Malayan Centre**:

It includes Indo-China and the Malay Archipelago. Fifty five plants , are listed , including banana, coconut, nutmeg , black pepper, manila hemp., mangosteen etc.

(III) Central Asiatic Centre:

This region includes North West India (Punjab, North West Frontier Provinces and Kashmir). Afghanistan, Tadjikistan and Uzbekistan (USSR) and Western Tian-Shan (China), Forty-three plants are listed, prominent among which are common wheat , pea, beans, lentil, spinach, apricot, almond, apple and pear.

(IV) Near Eastern centre:

This region includes the interior of Asia minor, all of Transcaucasia, Iran and the highlands of Turkmenistan (USSR). Eighty-three species are included in this region.

At least nine species of wheat as well as rye are indigenous to this centre. Many of our subtropical and temperate fruits (Cherry, pomegranate, walnut, quince, almond and fig) and several forage crops such as alfalfa, Persian clover and vetch are also native to this region.

(V) Mediterranean Centre:

This region includes the borders of the Mediterranean Sea. Eighty-four plants are known to have originated here including olives, and many cultivated vegetables (garden beet. Cabbage, turnips, asparagus) forage plants (Egyptian clover, white clover, Crimson clover): oil yielding plants (rape, black mustard): wheat's (durum and emmer) and spice plants (Caraway, anise, thyme, peppermint, sage, hops).

(VI) Abyssinian Centre:

Comprises Abyssinia (now Euthopia), Eritrea and parts of Somalia. Thirty-eight species are native to this region. Wheat and barley are especially rich in diversity and others include. Sesame, castor, bean, coffee and opera.

(VII) South-Mexican and Central American Centre:

This centre includes the Southern parts of Mexico, Guatemala, Honduras and costa Rice. Plants native to this region are extremely varied and tattoo, red pepper, upland cotton, sisal, papaya, guava, cacao and tobacco.

(VIII) South American Centre:

(A) **The Peruvian-Ecuadorean-Bolivian Centre:**

It consists mainly of high mountainous areas and represents the centre of pre-Inca civilization. Plants native to the Puna and Sierra uplands are also included. This centre is known to be the original home of many potato species, tomato, lima bran, pumpkins, red pepper, coca Egyptian cotton, quinine tree and tobacco.

(B) **The Chiloe Centre:**

It is an island near the coast of Southern Chile, is thought to be region of origin of the common potato.

(C) **The Brazilian-Paraguayan Centre:**

It is believed to be the region of origin of groundnut, cassava, pine-apple, rubber tree and cashewnut.

Eighty-five percent of the 640 species listed by Vavilov originated in the old world (Asia Europe and Africa) and the remainder from the new world (the Americas) .

All the centers of diversity are situated in the mountainous regions of the tropical zones of the old and New Worlds. The wide temperature fluctuations in these areas and the strong ultraviolet radiations are the causes of the origin of such a multitude of forms.

Vavilov further distinguished between primary and secondary or 'accumulation' gene centres. He suggested that in the primary gene centre, the process of domestication from the native wild relatives began and these are characterized by dominant genes. As the cultivated plants later migrated to another gene centre, they were subjected to same natural force which again led to a considerable increase in the diversity of the cultivated plants that came into this region.

In this way, a new or secondary gene centre develops from the cultivated plants in question, but significantly is characterized by a diversity of recessive characters and is also devoid of wild relatives. The Abyssinian centre is extraordinarily rich in varieties of wheat, barley, pea, flax and lentil but there are none of the wild relatives that are found in the Middle East, many thousands of kilometers from Ethiopia.

Thus, in the primary gene centre, the diversity was consequence of ancient cultivation. The longer a given biological entity occupies a given region, the larger would be the number of variables it would exhibit. (Willis, age-and- area hypothesis, 1992). But the reasons for secondary centres are ecological diversity, farming practice, human migration, patterns (different tribes are attracted to different races of a crop) and the internal biological dynamics of hybridization, segregation and selection.

Multiple Choice Question

1 The Central Arid Zone Research Institute (CAZRI) is situated at :
a) Jaipur
b) Jodhpur
c) Ajmer
d) Udaipur

2 Lichens are an example of :-
a) Protocooperation
b) Commensalism
c) Mutualism
d) Parasitism

3 Which of the following is an example of Commensalism?
a) Lichens
b) Epiphytes
c) Zoochlorellae
d) Zooxanthellae

4 The chemical basis of competition between plants is referred to as:
a) Allelopathy
b) Parasitism
c) Predation
d) Amensalism

5 Sea Anemone and hermit crab association is a type of:
a) Mutualism
b) Commensalism
c) Protocooperation
d) Amensalism

6 Which of the following is rooted submerged hydrophyte?
a) Hydrilla
b) Azolla
c) Lemna
d) Eichhornia

7 Aerenchyma is well developed in leaves and stem of :
a) Potamogeton
b) Eichhornia
c) Nymphaea
d) all the above

8 Sclerenchyma is well developed in organs of:
a) Casuarina
b) Aloe
c) Bryophyllum
d) Opuntia

9 Sunken stomata are characteristic of leaves of :
a) Nerium
b) Nymphaea
c) Nelumbo
d) Azolla

10 Pneumatophores are characteristic of :
a) Halophytes
b) Oxalophytes
c) Psammophytes
d) Heliophytes

11 Several species living together with mutual adjustment in a natural area are designated as a:
a) Biotic community
b) Population
c) Ecospecies
d) Ecophenes

12 Stratification is one of the characteristic of a :
a) Community
b) Population
c) Ecads
d) Ecological equivalents

13 Which of the following is relatively a major, larger unit of vegetation?
a) Faciation
b) Lociation
c) Association
d) Formation

14 Seasonal plants completing their life – cycle in a single season are also called :
a) Geophytes
b) Therophytes
c) Chamaephytes
d) Phanerophytes

15 Scientific study of seasonal changes in the life cycle of the plants is known as :-
a) Autecology
b) Phenology
c) Teratology
d) Synecology

16 Physiognomic methods of study of plant communities were given by:
a) Raunkiaer
b) Cowles
c) Post
d) Flahault

17 Buds , organs or seeds are protected most in a :
a) Therophyte
b) Cryptophyte
c) Chamaephyte
d) Phanerophyte

18 Which of the following is suitable for the study of forest community?
a) Belt transect
b) Point – frame\
c) Quadrat
d) Line transect

19 The final terminal stabilized stage of the plant succession is called:
a) Climax
b) Ecesis
c) Migration
d) Aggregation

20 Lichens are the primary colonizers:
a) In pond
b) On sand
c) In a swamp
d) On a rock

21 The hydrosere in a pond begins with:

a) Rooted submerged plants.
b) Phytoplanktons
c) Rooted plants with floating leaves
d) Rooted emergent plants

22 Which of the following is earliest stage in plant succession?

a) Nudation
b) Invasion
c) Reaction
d) Coaction

23 The whole sequence from beginning till the climax stage in a succession is called a :

a) Sere
b) Seral stage
c) Nudation
d) Ecesis

24 Rates of production are generally more than rates of respiration in :

a) Pond
b) Decaying forest litter
c) Heterotrophic succession
d) All autotrophic succession

25 Numerically the producers are more in their number in a

a) Forest
b) Grassland
c) Desert
d) Pond

26 Net primary production is higher in :

a) Temperate forest
b) Temperate scrubland
c) Tropical humid forest
d) Temperate deciduous forest

27 Which of the following was responsible for 'Minamata' epidemics?

a) Lead
b) Cobalt
c) Mercury
d) Strontium

28 Interlocking pattern of organisms based on their food habits is called a :
a) Food web
b) Biomagnification
c) Primary Production
d) Secondary production

29 Which of the following pyramids is always upright?
a) Biomass
b) Number
c) Energy
d) All the above

30 Which of the following moves always unidirectionally in an ecosystem?
a) Biomass
b) Carbon
c) Nitrogen
d) Energy

31 Continuous increase in concentration of a toxic chemical in a food chain is called:
a) Biomagnification
b) Biodegradation
c) Biodeterioration
d) Bioleaching

32 In a grassland , the top position in a food chain is occupied by :
a) Grass
b) Snake
c) Mouse
d) Hawk

33 The amount of inorganic substances present at any given time in an ecosystem is referred to as
a) Standing quality
b) Litter
c) Standing crop
d) Biomass

34 The rate of storage of organic matter in plant tissues in excess of utilization during their respiration is called:
a) Net productivity
b) Net assimilation
c) Gross primary productivity
d) Net primary productivity

35 Which of the following is the centre of origin of rice?
   a) India
   b) China
   c) Russia
   d) Indo- Malayan Region

36 The importance of ecosystem lies in :-
   a) Flow of energy
   b) Cycling of materials
   c) Both the above
   d) None of the above

37 Which of the following is the smallest unit?
   a) Biosphere
   b) Ecosphere
   c) Ecosystem
   d) Biome

38 In which zone of soil is humus maximum?
   a) O – Zone
   b) A – Zone
   c) B – Zone
   d) C – Zone

39 The character of the community based on external appearance of dominant plant is known as:
   a) Phenology
   b) Physiognomy
   c) Frequency
   d) Density

40 Pyramid of number may be inverted in :
   a) Forest Ecosystem
   b) Grassland Ecosystem
   c) Agriculture Ecosystem
   d) Marine Ecosystem

41 What is the basic feature of population?
   a) Natality
   b) Age distribution
   c) Density
   d) Mortality

42 Botanical Name of the jute plant is:
   a) Cannabis sativa

b) Musa textilis
c) Gossypium arboreum
d) Corchorus capsularis

43 Paddy can thrive well on :
a) alluvial soil
b) Sandy soil
c) Stony soil
d) clay to clay loam soil

44 The botanical name of barley is:
a) Hordeum vulgare
b) Avena sativa
c) Secale cereale
d) Pennisetum typhoides

45 The botanical name of pearl millet is :-
a) Hordeum vulgare
b) Setaria indica
c) Pennisetum typhoides
d) Sorghum bicolor

46 The quality of tobacco depends on :
a) curing process
b) its variety
c) agro – climatic conditions in which plant grows
d) all the above

47 The richest source of Vitamin A is:
a) Radish
b) Carrot
c) Lemon
d) Orange

48 Tea and coffee can be classified as :
a) distilled beverage
b) fermented beverage
c) alcoholic beverage
d) non – alcoholic beverage

49 Teak is obtained form ;
a) Dalbergia sissoo
b) Shorea robusta
c) Papaver
d) Adhatoda vasica

50 Triticum aestivum is :
a) Diploid
b) Triploid
c) Tetraploid
d) Hexaploid

51 The most important foods are derived from:-
a) roots
b) Stems
c) Leaves
d) Fruits

52 Asafoetida (Hing of commerce) is a gum resin obtained from:
a) Roots
b) Stem
c) Leaves
d) bark

53 Coconut oil derived from the copra can be classified as ;-
a) Essential oil
b) drying – oil
c) vegetable fat
d) Semi - drying oil

54 The commercial jute fibres are :
a) Xylem fibres
b) Bast fibres
c) Surface fibres
d) interxylary fibres

55 Para – rubber is obtained from :
a) Ficus elastica
b) Hevea brasilensis
c) Palaquium gutta
d) Castilla elastic

56 The sticky yellow resin which is exuded from the female flowers of Indian hemp plant is commonly known as :
a) Bhang
b) Ganja
c) Hashish
d) None of the above

57 Linseed oil is a :

a) Drying oil
b) Semi – drying oil
c) non – drying oil
d) vegetable fat

58 Beta vulgaris , an important source of sugar , belongs to the family:
a) Apocynaceae
b) Chenopodiaceae
c) Asclepiadaceae
d) Cruciferae

59 Teak wood , which is obtained from Tectona grandis belongs to the family:
a) Lamiaceae
b) Verbenaceae
c) Fabaceae
d) Sterculiaceae

60 Quinine is extracted from;-
a) Leaves
b) Fruit
c) Root
d) Stem bark

61 Mangrove vegetation is :
a) Mesophytic
b) Halophytic
c) Lithophytic
d) Xerophytic

62 Plants which grow in alpine region are called:
a) Megatherms
b) Mesotherms
c) Microtherms
d) Hekistotherms

63 Succession as a result of interaction of organisms and environment is known as:
a) Autogenic
b) Allogenic
c) Primary Succession
d) Secondary Succession

64 The State tree of Rajasthan is :

a) Capparis decidua
b) Prosopis cineraria
c) Zizyphus rotundifolia
d) Casuarina

65 An ecological pyramid refers to the :
a) Pyramid of energy
b) Pyramid of numbers
c) Pyramid of biomass
d) all of the above

66 Energy flow in an Ecosystem is always :
a) Unidirectional
b) Cyclic
c) Reversible
d) Multi – directional

67 Which of the following is a possible producer in an Ecosystem/
a) Plants
b) Animals
c) Human beings
d) Fish

68 Incoming solar radiation is called:
a) Insolation
b) Albedo of earth
c) Terrestrial radiation
d) Convection

Q69 Which of the following lies nearest to the earth's surface?
a) Stratosphere
b) Troposphere
c) Mesosphere
d) Ionosphere

70. Direction of mountain chains and valleys , altitude and exposure of slope are included among:
a) Climatic factors
b) Biotic factors
c) Edaphic factors
d) Physiographic factors

71 Plants growing best in full sunlight are called ;
a) Sciophytes
b) Therophytes

c) Heliophytes
d) Halophytes

72 Which of the following forms of water in the soil is largely available to plants?
a) Hygroscopic
b) Capillary
c) Gravitational
d) Combined

73Dissolution of the mineral component of rock by chemicals secreted by lichens and bacteria is called:
a) Chelation
b) Carbonation
c) Glaciation
d) Solution

KEY TERMS

1. **Amensalism**: Symbiosis in which one organism is inhibited by the other but the later remains unaffected.
2. **Atmosphere:** The gaseous envelope surrounding a planet.
3. **Autoecology:** Ecology of individual organism or species.
4. **Benthos:** Organisms living on or at the bottom of water body.
5. **Bioenergetics:** Study of energy transformations in living systems.
6. **Biogeochemical Cycles:** Pathways of circulation of elements within an eco system.
7. **Biological monitoring:** Direct measurement of changes in the biological component of a habitat based on evaluation of the number and/or distribution of organisms or species (before and after the change).
8. **Biomass:** Standing crop (living matter) of living organisms, in terms of weight, present at any given time in the environment.
9. **Biome:** A major ecological community of organisms (a complex of several communities, may be under different succession stages) maintained under a particular climate zone.
10. **Biosphere:** The planet earth along with its living organisms and atmosphere which sustains life i.e. the earth and atmosphere in which organisms live.
11. **Biota:** The flora and fauna of an area.
12. **Canopy:**
    A leafy portion of a tree or a shrub
13. **Climax (Community):** The final, terminal, stable community (developed in process of succession) that maintains itself for over longer period in equilibrium with the prevailing environmental condition .The stage is known as climax.
14. **Commensalism:** Symbiotic association where one species is benefited and the other not harmed (or unaffected).
15. **Decomposers:** Microbes that obtain their nutrition from breakdown products of dead organic matter.

16. **Deforestation:** Destruction of forest cover and the undergrowth.
17. **Detritus:** Dead organic matter, mainly of fallen leaves as leaf litter in forests. The microbes decomposing detritus are called detritivores.
18. **Ecad:** A form of a plant modified by its habitat .The modifications are somatic (induced by environment) and thus not heritable.
19. **Ecesis:** The process of successful establishment of a species in a new area (in process of succession).
20. **Ecological balance:** Maintenance of equilibrium between living components of an ecosystem, so that it remains stable system.
21. **Ecology:** The science of relationship between living organisms and their environment
22. **Ecosphere:** Ecological system formed by interaction of co-acting organisms and their environment. A group of interacting organisms along with their environment, that operates as a system.
23. **Ecosystem:** Ecological system formed by interaction of co-acting organisms and their environment. A group of interacting organisms along with their environment, that operates as a system.
24. **Ecotone:** A transition zone between two adjacent biomes containing some organisms, from adjacent biomes and some characteristic ones restricted to the zone itself.
25. **Ecotype:** A genetically different population of a species colonizing a different specific habitat. Different ecotypes are however, inter-fertile.
26. **Endemic:** Confined to a given region.
27. **Energy flow:** The passage of energy through the tropic levels of a food chain.
28. **Environment:** The sum of all physical, chemical, biotic and cultural factors that affect life of organism in any way.
29. **Eutropic:** Refers to lakes that are highly, productive in terms of organic matter formed, and well supplied with nutrients.
30. **Exosphere:** Outermost layer of atmosphere lying beyond the ionosphere. In exosphere, there are 50% chances of a molecule to escape in the space.
31. **Fauna:** Species content of animals present in any area.
32. **Food chain:** A series of organisms arranged in a linear manner with repeated eating and being eaten.
33. **Food Web:** Interlocking pattern of several interlinked food chains.
34. **Forest:** A biome in which dominant plants are trees.
35. **Grass Land:** Herbaceous vegetation dominated by grasses.
36. **Green house effect:** Heating of air caused by allowing incoming solar radiation but inhibiting outgoing radiation. The warm air inside green house causes its heating.
37. **Habit:** Appearance (external outlook) of an organism.
38. **Habitat:** The place where an organism lives in nature.

39. **Hekistotherm:** A plant which grows under very low temperatures (generally in alpine area).
40. **Heliophyte:** A plant which grows best in full sunlight.
41. **Homoeostasis:** The tendency of the biological system to resist change and to remain in a state of equilibrium.
42. **Hydrosphere:** The part of the earth composed of water (ocean, sea, icy cap, lake, river etc.)
43. **Humus:** More or less decomposed finely divided amorphous organic matter in the soil.
44. **Ionosphere:** Layer of uppermost atmosphere extending upwards from about 80 Km above the surface up to 300 Km, in which atoms tend to be ionized by incoming solar radiation.
45. **Land - reclamation:** Treatment of barren land usually by filling with refuse so that land could be made productive.
46. **Lentic water:** Standing water (lake, pond).
47. **Life form:** A type of plant, the sum of the adaptation of the plant to a climate type.
48. **Limnetic (Zone):** Living in open water zone, a depth where effective light may penetrate.
49. **Lithosphere:** The crust and mantle (solid portion) of earth.
50. **Littoral (zone):** A shallow water region near sea-shore, lying between high and low tide levels. Also, shallow water region in a lake or pond.
51. **Macrophytes:** Large aquatic plants.
52. **Meadow:** A piece of permanent grassland especially cut for hay.
53. **Megatherm:** A tropical plant, needing continuous higher temperatures.
54. **Mesosphere:** Part of atmosphere extending from the ionosphere to exosphere (400 to 1000 Km above earth surface). Also part of atmosphere between the stratosphere and thermosphere (40-80 Km above the earth surface).
55. **Mesotherm:** A plant of warm areas.
56. **Mutualism:** An association where both organisms are mutually benefited, unable to survive in isolation.
57. **Nekton:** Organisms that swim in water.
58. **Niche:** The specific physical space occupied by an organism, the functional role of an organism in ecosystem.
59. **Oligotrophic:** Lakes poorly productive in terms of organic matter and poor in nutrients.
60. **Organic farming (Biological husbandry):** Farming without artificial fertilizers or pesticides.
61. **Ozone layer:** A layer of atmosphere (above 30-50 Km above earth surface) which contains ozone produced by UV radiation.

62. **Phenology:** Study of periodical changes in plants in relation to seasons of a year.
63. **Phytoplankton:** Floating or fully suspended plants.
64. **Population:** A group of inbreeding individuals of a species.
65. **Predation:** One organism is eaten by another.
66. **Profundal zone :** The zone of a lake lying below the compensation depth.
67. **Psammophyte:** A plant growing in sand.

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