Unit 1

INTRODUCTION TO PLANT ECOLOGY

Structure

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1.1 INTRODUCTION

Organisms do not live in isolation. All organisms are linked to their surroundings. The survival of an organism thus depends upon its surroundings. These surroundings of an organism constitute its (are called as - delete) environment. Any change in the surroundings/environment affects the growth and survival of living organisms to a significant extent. Nutrients and energy get distributed among various living components present in a particular environment. Ecology is the study of the relationship of organisms i.e. plants, animals, microorganisms with their surroundings (environment). Ecological studies deal with the relationships of organisms with their environment. The present unit provides information about basic concepts in ecology.

Expected Learning Outcomes

After the study of this Unit, you should be able to

- define various terms used in ecology (environment, population, community, ecosystem and ecosphere),

- describe subdivisions of ecology,
- outline differences between natural and man-made environment,
- describe components of the ecosystem,
- enlist characteristics of the community,
- enumerate knowledge about recent developments in the field of ecology, and
- discuss the interrelationships between ecology and other disciplines of biology.

1.2 WHAT IS ECOLOGY?

Hanns Reiter (1868) gave the concept of ecology. The term 'ecology' is derived from two words '*oikos*' meaning home and '*logos*' meaning study. The term was (given by -delete) coined in 1869 by the German biologist Ernst Haeckel. Literally it means 'study of home'. According to him ecology is a branch of science which deals with the study of interrelationship between living organisms and their surroundings (environment). Scientifically 'ecology' has been defined as 'study of inter-relationships of organisms with their surroundings. Various other definitions have been given by (other – delete) different scientists. Woodbury (1954) defined ecology as "science that investigates organisms in relation to their environment'. E.P. Odum (1969) defined ecology as "the study of structure and function of nature".

1.3 HISTORY OF ECOLOGY

Ever since man occupied this planet, s/he has been very closely linked to her/his surroundings. Thus, early man obtained all the basic needs – food, clothing and shelter – from the surroundings. The Greek scholar, Theophrastus (370-250 BC) was the first person to introduce a scientific/ecological approach to the world. He described the relationship between organisms and the environment in scientific terms. (History records mention that organisms survive in natural conditions since ancient times – delete). In the 18th century, European naturalist, French Gorges Buffon (1707-1788) introduced the concept of ecology by describing the relationship of animals to their environment in his book on Natural History. Plant geographers such as Carl Ludwig Willdenow (1765-1812) pointed the role of environment/surroundings in the development of vegetation. A Swedish naturalist, Carl Linnaeus (1707-1778) laid the grounds of modern ecology around 250 years ago. He studied all kinds of organisms – plants, animals, etc. – as well as the types of minerals and soils. (developed a system of naming plants and animals called as Binomial Nomenclature. According to this system, name of each living organism consists of two parts - genera and species – delete). The German explorer, Alexander von Humboldt (1769-1859) studied relationship of vegetation and environment during his travels to various parts of the world. He compiled his findings in his book '***Voyage aux regions equnoxalis'***. He described vegetation zones based on

latitude and altitude. He correlated vegetation with environmental characteristics and coined the term 'plant association'. Charles Darwin (1809-1882) gave the theory of 'Natural Selection' in his book '**Origin of Species'**. He compared the similarities and dissimilarities between species found in different regions. He attributed differences in the species to geological barriers. The theory was based on the concept of competition between species. Herbert Spencer (1820-1903) was considered as the founder of social ecology gave the concept of 'survival of the fittest'. Most of the studies carried out in the 19th century focused on animal behavior. (The contributions of – delete) Some renowned ecologists (that – delete) who have contributed (a lot – delete) to the development of ecological studies have been listed below.

Ecologists and their contribution to modern ecology.

	Ecologists	Year	Contribution to field of ecology
A.	Lavoisier and de Saussure	(1734-1794)	Described the nitrogen cycle. He defined various compartments of biosphere namely atmosphere, hydrosphere, and lithosphere.
	Thomas Robert Malthus	(1766-1834)	Gave the concept of 'population'
	I. Geoffroy Saint-Hilaire	(1805–1861)	Gave the term 'ethology' years before term the term 'ecology' was coined.
	Kerner	(1831-1898)	Gave account of vegetation and succession in book 'Plant Life of Danube Basin'.
	Ernest Haeckel	(1834-1919)	Coined/ used (Invented- delete) the term 'ecology' for the first time in science.
	A. Schimper	(1856-1901)	Explained the regional flora in book 'Plant Geography'.
	Alfred Russel Wallace	(1858)	Proposed "geography" of animal species. He grouped living organisms into communities.
	Karl Möbius	(1877)	Coined the term 'biocoenosis' meaning living community.
	J. Warming	(1841-1924)	Integrated morphology, physiology, taxonomy and biogeography into one branch of science. He wrote first text on plant ecology, '***Plantesamfund***'. Described various types of vegetation. He introduced the terms 'hydrophytes, xerophytes,

		halophytes and mesophytes'.
Eugenius Warming	(1841-1924)	Emphasized role of abiotic factors and introduced term 'adaptation' to explain behavior of species under set of environmental conditions. He is the founder of Ecological Plant geography.
Vladimir Vernadsky	(1869-1939)	Gave the concept of 'biosphere'
H. C. Cowles	(1869-1939)	Published books on vegetation dynamics and ecological succession.
Arthur G. Tansley	(1871-1955)	He combined living organisms and their physical environment into one system. He gave the term 'ecosystem' (1936). He is the founder of British Ecological Society.
Fredric E. Clements	(1874-1945)	Published book on the phytogeography of North America (1905). He considered ecology as 'the science of community'. He stated that development of plant community is a complex process growing through different stages.
V.E. Shelford	(1877-1968)	Defined ecology as 'science of communities'. He gave the terms 'food web' and 'biome'. He showed interrelationship between plant and animals.
Charles E. Elton	(1900-1991)	Father of animal ecology. Coined the terms 'food chain' and 'food cycle' in book named 'Animal Ecology'.
R. Hesse	(1927)	Wrote a book 'Ecological Animal Geography'
G. Evelyn Hutchinson	(1903-1991)	He is called as "Father of Modern Ecology". He gave the concept of limnology, entomology, mathematical theory of population dynamics. He introduced the concept of 'niche'.
Vladimir I. Vernadsky	(1920)	Detailed the idea of the biosphere and described 'biogeochemical cycles'.
Christien Raunkier	(1934)	Gave the concept of life form in

		plants.
William Wheeler and Charles Carpenter	(1956)	Gave the concept of 'Behavioral ecology'.
Macfadyen	(1957)	Emphasized the role of relationships between living organisms and environment.
J. Braun Balnquet	(1958)	Studied lake ecology. He trained two Indian ecologists R. Misra and G. S. Puri
Eugene P. Odum	(1913-2002)	Defined ecology as the science of ecosystems. Contributed to modern ecology through books 'Fundamentals of Ecology', 'Ecology and Basic Ecology'.
Howard T. Odum	(1924-2002)	Cofounder of 'Ecosystem ecology and thermodynamics'.
R. A. Lindeman	(1942)	Gave the concept of 'ecological energetics'. He traced energy relationships within organisms present in a lake community. Gave the ecological models and concept of ecosystem ecology.
F.H. Borman, J.S. Olson	(1976)	Worked on cycling of nutrients and water
R.G. Weigert	(1976)	Studied 'Ecological Energetics'
Harper	(1977)	Gave a book on 'Unified Study of Animals and Plants'
Began and Mortimer	(1981)	Gave an update on 'Population Ecology'
B. Bolin and R.B. Cook	(1983)	Edited a volume on 'The Major Biogeochemical Cycles and their interactions'.

In the Indian scenario, ancient/classical epics and holy books such as Ramayana, Mahabharata, Vedas, Samhitas, Brahmanas, and Araanyakas-Upnishads provide a mention of basic ecological concepts. The Charak-Samhita and Susruta- Samhita ancient Indian texts on medicine, and surgery mentioned the role of plants in treating human ailments. These records showed that people during ancient times had good understanding of plant and animal ecology. The basic concepts of ecology in India began with the study of

forest vegetation by forest officers. The first comprehensive account was given by Professor Dudgeon from University of Allahabad. He discussed the role of environment in succession of communities. Extensive synecological studies were carried out on grassland and forest communities in India. Professor R. Mishra (1944, 1945) studied ecology of aquatic plants and has been referred as 'father of Indian ecology'. He gave methods of soil analysis and established 'Society for Tropical Ecology' in 1958 and 'School of Ecology' at Banaras Hindu University in 1960.

As the studies advanced, the ecological concepts were linked to other disciplines of biology and science. With passage of time, ecological researches became more applied to human welfare. The studies on the effect of changes in the environmental conditions such as pollution on various types of vegetation and other components of environment were initiated. Agencies such as MAB (Man and Biosphere programme of UNESCO) and IUCN (International Union for Conservation of Nature and Natural Resources, Switzerland) that focused their work on biological basis of productivity and human welfare were formed.

SAQ 1

Discuss in brief the contributions of various scientists in the development of modern ecology.

1.4 SUDIVSIONS OF ECOLOGY

Ecology is divided into two types namely animal and plant ecology. The division was based on the category of organisms studied. In modern system, ecology has been divided into two types**:** autecology and synecology. The division has been made on the basis of study of individual organism or a group of organism.

Autecology is the study of individual species in relation to their environment. It includes the study of geographical distribution, taxonomic position, morphological characters, reproduction, life cycle and behavior of species with reference to ecological factors or environment.

Synecology is the study of a population or community in relation to their environment. It comprises of community and ecosystem ecology. The composition and behavior of communities and their relationship to the environment are studied.

It has also been broadly classified into two types depending upon the study of habitat.

- Aquatic Ecology – This includes study of living organisms present in fresh water, estuarine and marine habitat.

- Terrestrial Ecology**-** This includes study of living organisms present in forest, grassland, cropland and desert habitats.

Other subdivisions of ecology have been made on the basis of the aspect of ecology studied (Fig 1.1). These mainly include

Organism ecology – It is based on relationship of living organisms (animal and plants) to biotic and abiotic factors in their environment.

Behavioral ecology – It is study of behavior of living organisms in relation to changing environmental conditions.

Population ecology – It is the study of structure and dynamics (size, density, dispersion, demographics) of population in relation to environment. Variations in growth and regulation of a population (this word – demonology - is inappropriate here. Its dictionary meaning is the "study of demons" or "black magic". The word demography could be used. It is defined as "the statistical characteristics of human populations) are considered.

Community ecology – It deals with structure and organization of a biological community with respect to environmental interactions. Factors such as structure, biodiversity, distribution, abundance of species and interactions such as predation, herbivory, competition, parasitism and mutualism are studied.

Ecosystem ecology – It is the study of living organisms (animals, plants and microorganisms) along with the non-living components of their environment (water, air and soil). The aspects such as nutrient and energy flows are considered.

Taxonomic ecology – It is study of different taxonomic groups of living organisms in relation to their environment. It includes microbial ecology, mammalian ecology, insect ecology, human ecology.

Physiological ecology/Eco-physiology – It is the study of changes in the physiological procedures/functions such as nutrition and metabolism in living organisms in response to environmental factors. Various adaptations in organisms under different ecological conditions are studied.

Chemical ecology – It is study of adaptation of animals or insects with respect to production of chemical substances.

Palaeoecology – It is the study of organisms and their environment in the geological past. Cytoecology- It deals with the study of cytological details of the species in relation to environmental conditions.

Production ecology / ecological energetics – It is the study of energy conversion and flow through different organisms in relation to space and time.

Ethology – It is the study of animal behavior in different environments.

System ecology – It is analysis of structure and function of an ecosystem using applied mathematics or statistics.

Habitat Ecology – It is the study of living organisms in different habitats.

Besides these some other branches of ecology such as conservation ecology, production ecology, space ecology, radiation ecology has also been recognized.

In an ecological system, various levels of biological organization (hierarchy) are noted. These range from individual organisms to the biosphere. Various units included in hierarchy include organisms, populations, communities, ecosystems and the biome. Hierarchy is the system of grouping organisms at different levels (Fig 1. 2). The levels of organization connected with ecological grouping are called ecological hierarchy.

i) An individual (organism) is the basic and distinct unit of ecological hierarchy. Individuals carry out all life processes and exchanges materials with the surroundings.

ii) A population is a group of individuals of the same species living together in a common area at a particular time.

iii) A community is the assembly of populations of different organisms in a particular environment.

iv) The ecosystem is the association of living and non-living components present in a particular environment of an area.

v) A Biome is the group of terrestrial ecosystems present at the regional or sub continental level.

vi) The Biosphere is the part of the earth where life is present. It comprises of atmosphere (air), lithosphere (land) and hydrosphere (water).

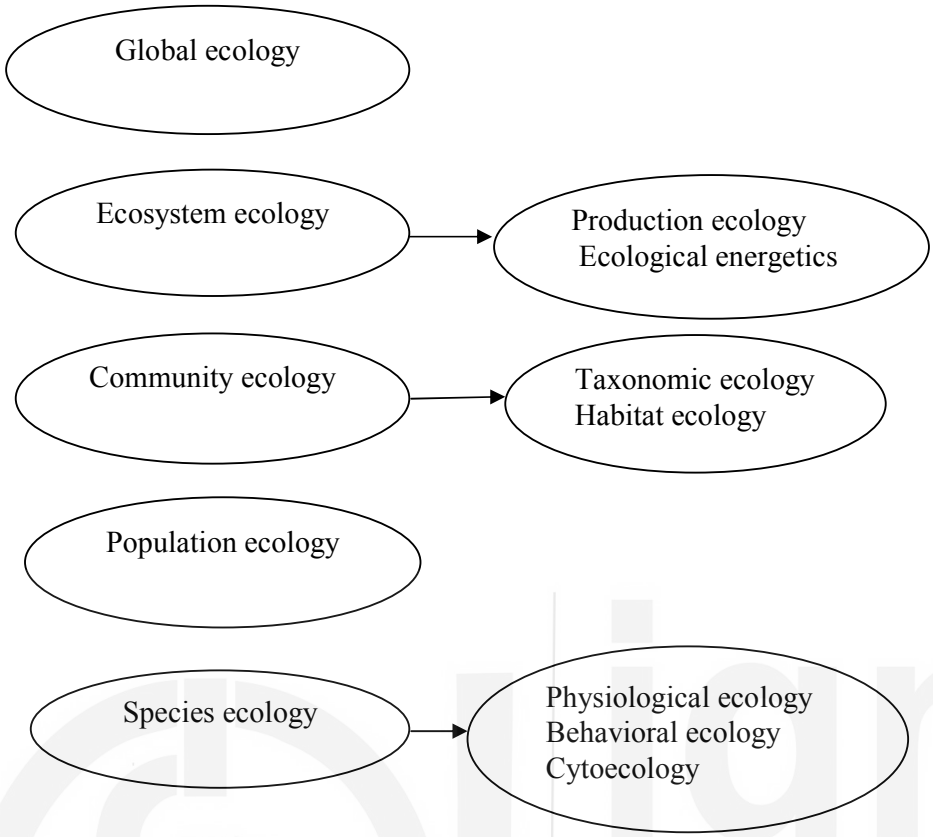


Fig. 1.1: Study of ecology at various levels.

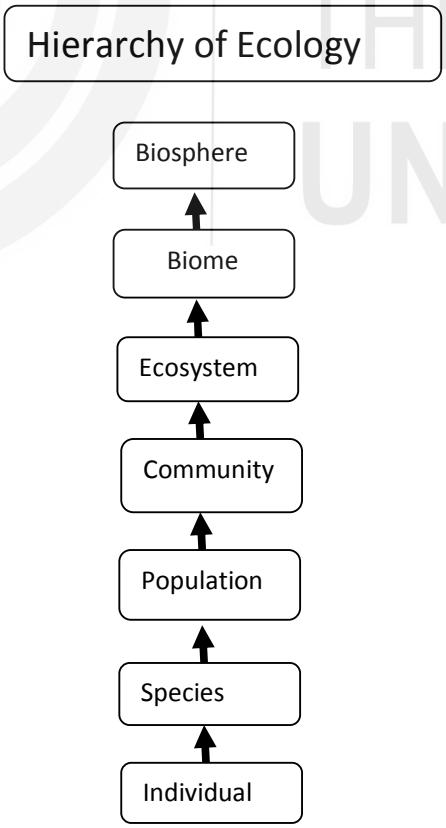


Fig. 1.2: Various levels of hierarchy known in ecology.

SAQ 2

List the major differences between

a. Synecology and autoecology

b. Aquatic and terrestrial ecology

c. Community and ecosystem ecology

1.5 RELATIONSHIP OF ECOLOGY WITH OTHER DISCIPLINES OF BIOLOGY

Ecology is an integrated science. The interactions taking place within an ecological system is complex and involves various kinds of physical, chemical and biological processes. The dependence of ecology on other branches of science makes it an interdisciplinary science. All the living organisms i.e. plants, animals and microorganisms form an important component of ecological study. The survival, distribution and abundance of these organisms are influenced by changes in physical factors such as temperature, light, rainfall and altitude. Branches of science such as geology, hydrology and metrology influence the survival and distribution of biotic communities to a greater extent. The branches of biology such as zoology, botany, microbiology were integrated into ecology so that structural and biochemical processes involved in the adaptation of organisms to changing environmental conditions can be studied. Interactions between living organisms is studied using various aspects such as morphology, physiology, genetics, taxonomy, molecular biology, developmental biology, ornithology, bacteriology and entomology (Fig 1.3). The relationship of ecology with other divisions of sciences can also be represented by model of cake (Fig 1.4) in which various layers represent basic divisions of biology, taxonomy, genetics, molecular biology. The thicker slices represent higher divisions of biology such as botany, zoology, microbiology while thinner slices represent divisions such as phycology, ornithology dealing with specific organisms. Each organism is studied considering various aspects such as morphology, genetics, evolution, physiology, developmental biology, molecular biology etc.

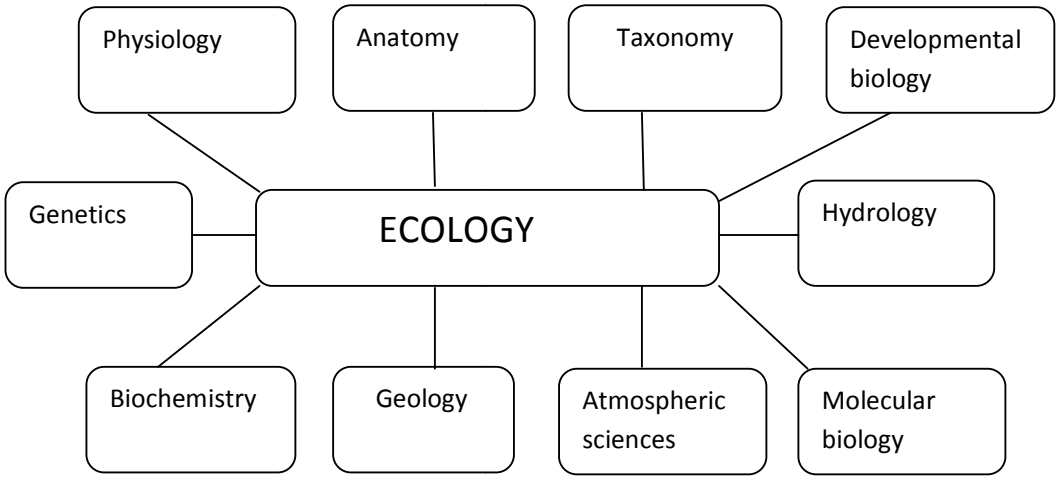


Fig. 1.3: Interrelationship of ecology with other disciplines of science and biology.

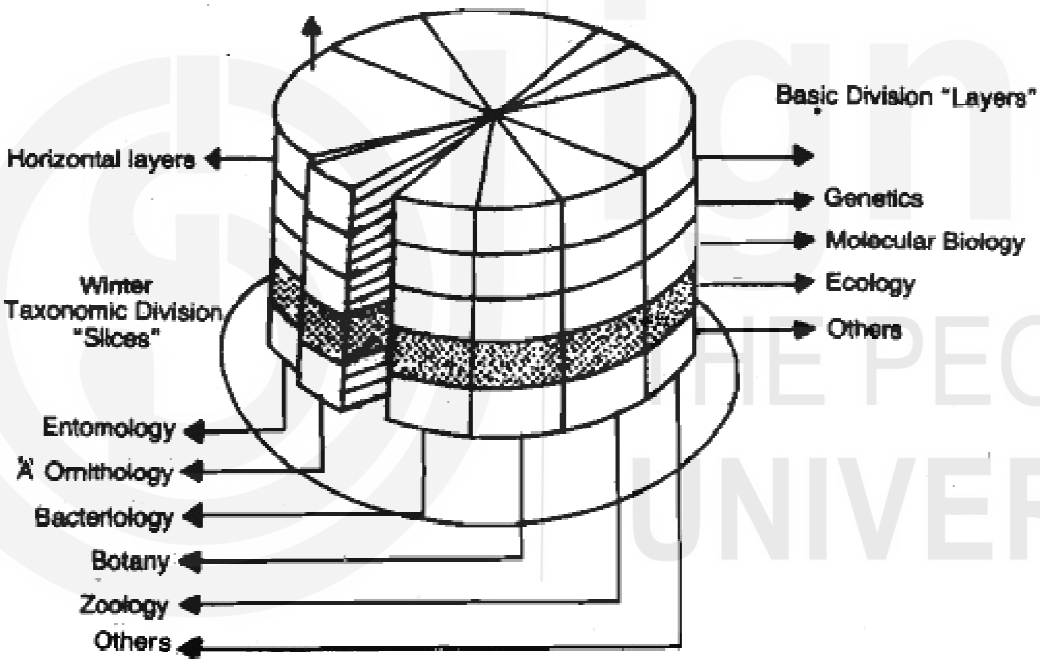
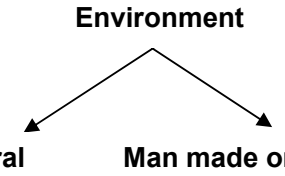


Fig. 1.4: The layered biological cake showing relationship of ecology with other disciplines of biology.

1.6 BASICS OF ECOLOGY

1.6.1 Environment

Each living organism depends on its surroundings for survival and sustenance. Environment provides food, energy, water, oxygen, shelter and other necessities to living organisms. The total of all of the surroundings – air, water, land, vegetation that influence the existence of living beings is referred to as environment. Environment is broadly classified into two types natural and manmade.



Created naturally

(Examples- Mountains, lakes)

Created by man by altering natural conditions

(Examples- cultivated fields, cities, townships)

Components of environment

Environment consist of two components

- Living or biotic
- Non-living or abiotic

Biotic components- All the living components are referred as biotic components. These include plants, animals and microorganisms.

Abiotic components – All non-living factors are called as abiotic components. These include water, air, soil/land, and physical factors such as light and temperature.

External and internal environment

Organisms possess an internal environment which is enclosed by outer body surface. The body surface acts an exchange barrier between external and internal environment. In single celled organisms, exchange of materials is carried out directly with the external environment (Fig 1.5). Internal environment is relatively more stable as compared to the external environment.

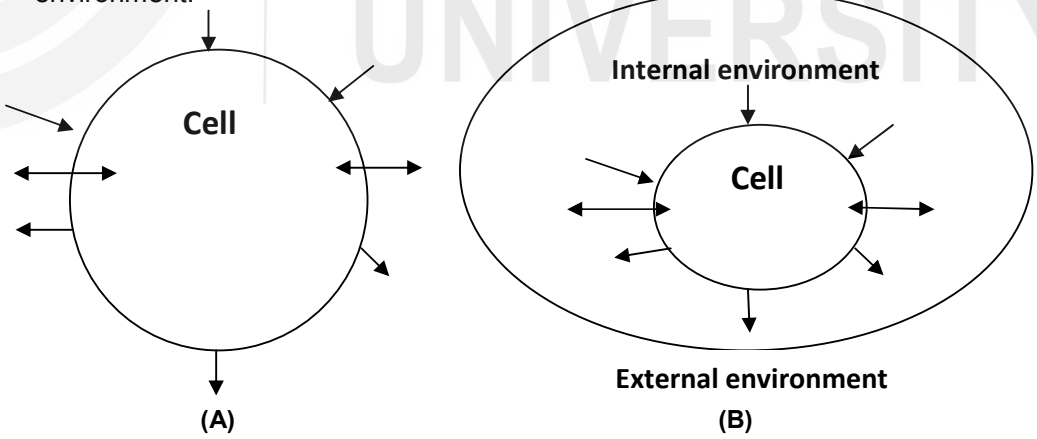


Fig. 1.5: External and internal environment in (A) Unicellular (B) Multicellular organism.

SAQ 3

Describe the various components of environment.

1.6.2 Biosphere

The part/zone/layer of earth where life exists is referred as biosphere (ecosphere). The global ecological system is composed of all living beings and elements of lithosphere (rock), hydrosphere (water), and atmosphere (air). It is a closed self-regulating system. It regarded as the sum of all ecosystems (Fig 1. 6). The biosphere is supposed to have evolved from the process of biogenesis (life created from living matter) around 3.5 billion years ago. The biosphere extends from 11,000 meters below sea level to 15,000 meters above it. The concept of term biosphere was given by English geologist Eduard Suess (1831-1914) and Russian physicist Vladimir I. Vernadsky (1863-1945).

Hydrosphere (water) – Water constitutes around 70% of the earth's surface. It includes water resources such as oceans, seas, rivers, lakes, streams, ponds, glaciers, polar ice caps and ground water. About 97% water is present in oceans and seas, 2% in ice caps and the remaining 1 % as fresh water.

Lithosphere (Land) - It is the solid component or the hard surface (crust) of earth. It consists of three layers: crust, mantle and core. The uppermost part consists of weathered rocks, minerals and organic matter and is known as soil. The mantle and core form the inner layer of lithosphere.

Atmosphere (air) – It consists of a complex mixture of gases, water vapor and particulate matter. This layer sustains life on earth by providing gases such as oxygen and carbon dioxide essential for photosynthesis and respiration in living organisms. Atmosphere is divided into different zones such as troposphere, stratosphere, mesosphere, thermosphere, magnetosphere depending upon temperature gradients.

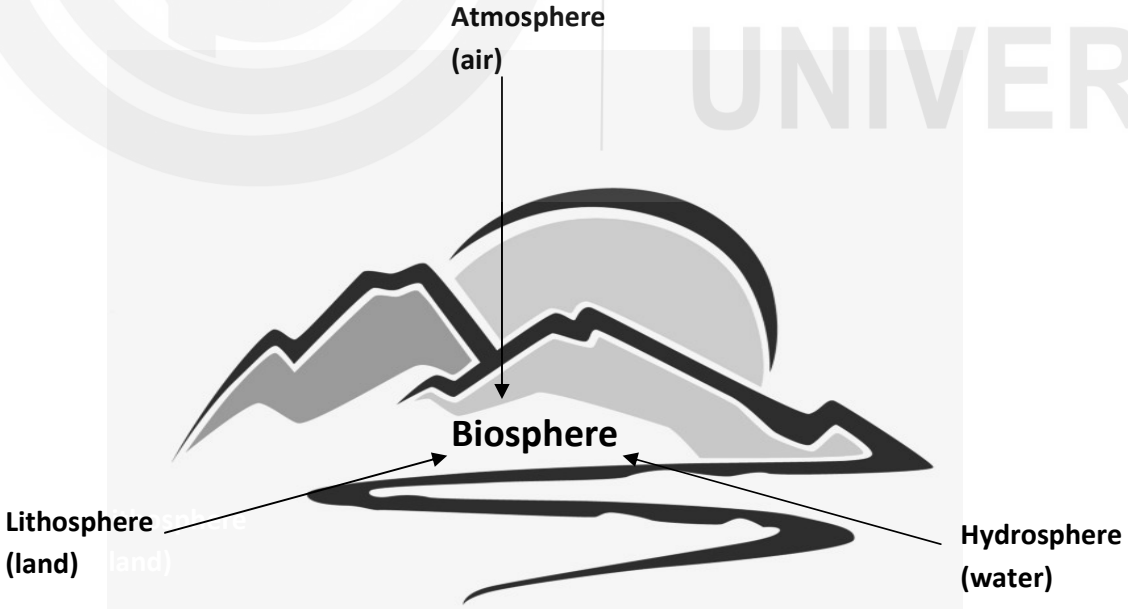


Fig. 1.6: Depiction of the biosphere.

1.6.3 Ecosystem

An ecosystem is an ecological unit composed of living and non-living things. The living or biotic components interact with non-living or abiotic components of the environment and maintain the equilibrium in the environment. Arthur Tansley (1935) proposed the term 'ecosystem' and defined it as interaction of all living and non-living components of the environment.

Components of the ecosystem

a. Abiotic Components

These include the non-living or physico-chemical factors. They support the biotic components. They restrict the growth, number and diversity of the population of a species and hence called as limiting factors. These components vary from one ecosystem to another. These factors are classified broadly under three categories:

Climatic factors – These include physical factors such as light, temperature, wind, humidity.

Edaphic factors – These include soil, its structure and properties. Parameters such as soil type, soil profile, organic matter, minerals, soil and soil organisms are included in it.

Physical factors – These include water, air.

Materials- It includes inorganic components such as carbon, sulphur, nitrogen, phosphorus etc. All these elements circulate in different components of ecosystem via biogeochemical cycles. The organic components of an ecosystem are proteins, carbohydrates, lipids and amino acids. These are synthesized by biota (flora and fauna) of an ecosystem.

b. Biotic components

Biotic components are the living components of the ecosystem (Fig 1. 7). These include plants, animals, and micro-organisms. They act as autotrophs, heterotrophs and saprotrophs. They have a direct or indirect influence on other organisms present in an ecosystem.

Producers (autotrophs) -They are autotrophic in nature i.e. convert energy procured from sun into food. They include photosynthetic organisms. They are called as producers, transducers or convertors. In terrestrial ecosystems, producers are green plants. In the aquatic ecosystems, the floating plants (referred as phytoplankton) and rooted plants (called macrophytes) are the main producers. Freshwater and marine ecosystems consist of algae as the dominant producers. The photosynthetic plants bear chlorophyll and synthesize a high-energy complex organic compound (or food) from the inorganic raw materials utilizing sunlight through a process called photosynthesis.

Consumers - They are heterotrophic organisms. They eat food produced by autotrophs. Herbivores take their food directly from the producers i.e. they eat plants, hence also referred as primary consumers. Carnivores feed on

animals, hence referred as secondary consumers. Tertiary or quaternary consumers include organisms that feed on secondary carnivores. Omnivores mainly include humans that feed on both plants and animals.

Decomposers -They include microorganisms such as bacteria and fungi. They are also referred as saprotrophs or reducers. Scavengers, detritivores and decomposers feed on dead decaying matter and produce organic constituents. The breakdown of nonliving organic matter into inorganic matter occurs via digestive enzymes secreted by microorganisms. In the process of conversion, recycling of the essential nutrients takes place. The remaining substances are added as minerals in substratum through the process of mineralization.

In an ecosystem, various components interact with each other. Biotic components depend on abiotic components for their survival. Abiotic components such as soil get enriched by organic matter added after decay and decomposition carried out by microbes or saprotrophs.

At functional level of an ecosystem, primary producers (plants) harvest energy from the sun through the process called photosynthesis. This energy is transferred from plants to other organisms i.e. **consumers which** include both herbivores and carnivores (Fig 1. 8). Later on energy gets transferred to fungi and bacteria via death/decay and decomposition process. There is a continuous flow of nutrients and energy in an ecosystem. The organic constituents produced after decomposition can again be used by producers.

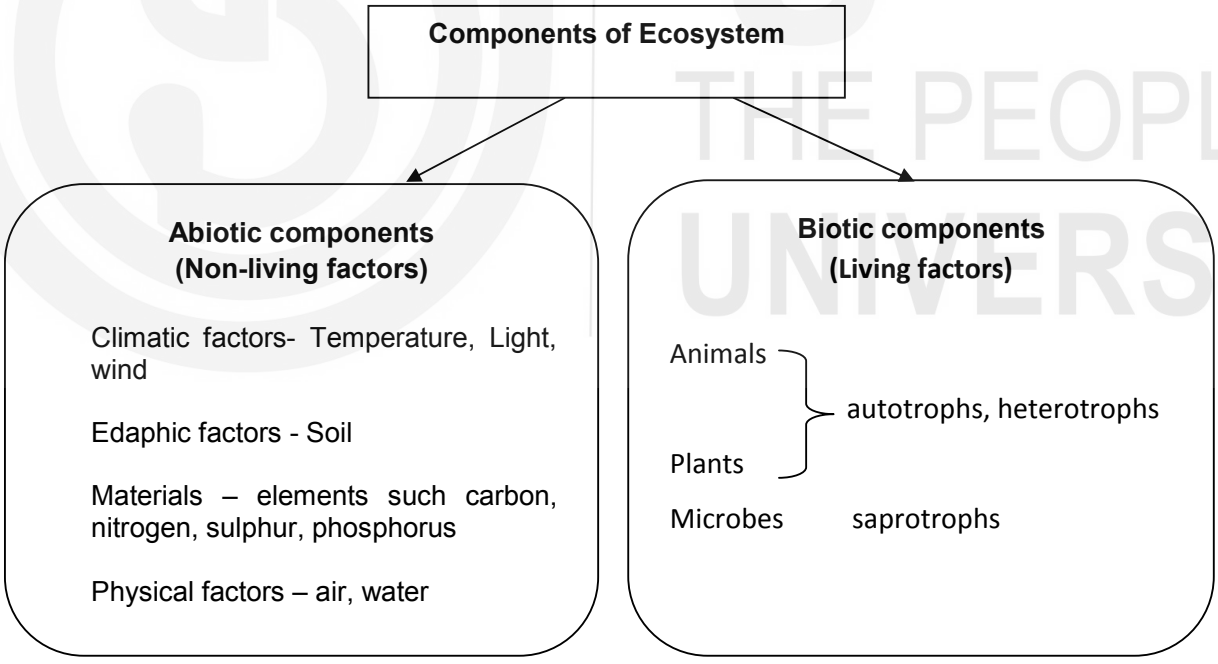


Fig. 1.7: Components of an ecosystem.

Types of ecosystem

Ecosystems are broadly classified as :

- Natural – these ecosystems develop naturally without interference of human beings. Example forests, lakes, deserts.

- Artificial or manmade – these ecosystems are developed by humans after modification of natural ecosystems. Example forests were transformed in crop fields, smart cities, gardens and dams (Fig 1.9).

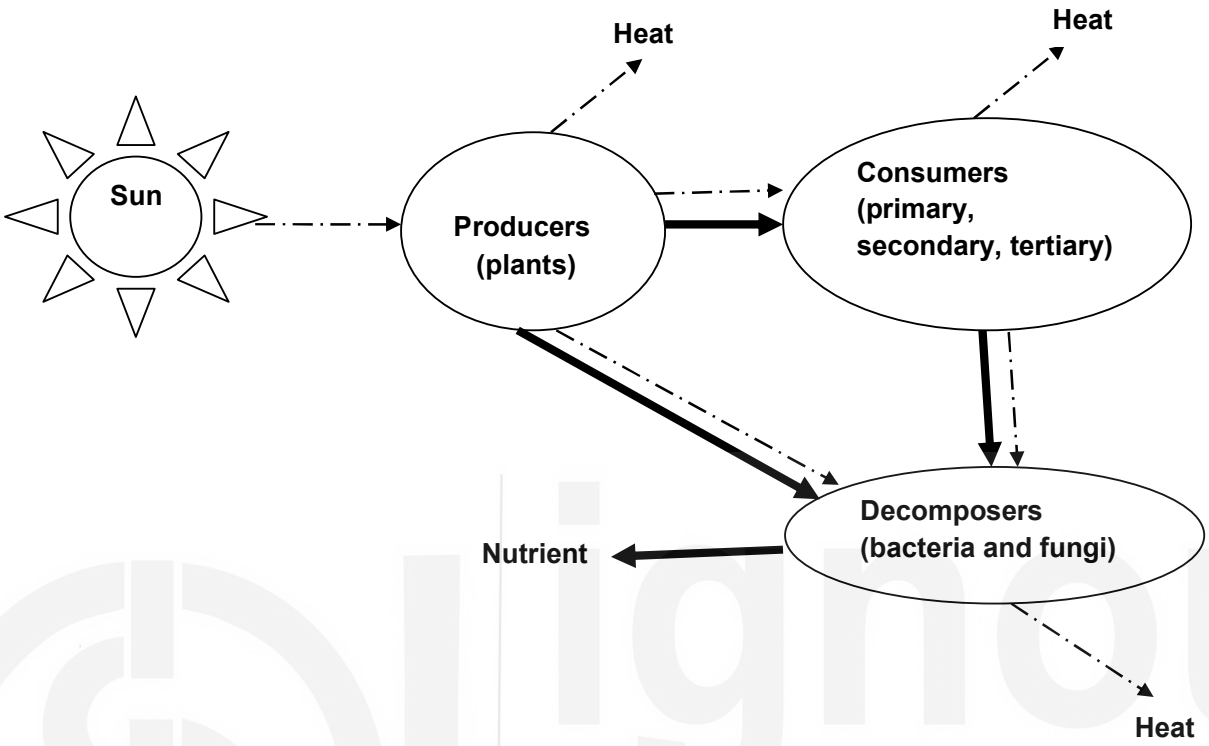


Fig. 1.8: Energy and nutrient flow through various biotic components of an ecosystem.

Ecosystems have also been classified into two types depending upon the size.

- Micro-Ecosystems- small ecosystem. Example -drop of water.
- Macro-Ecosystem- big ecosystem. Example- Caribbean Sea, mountain range of Andes.

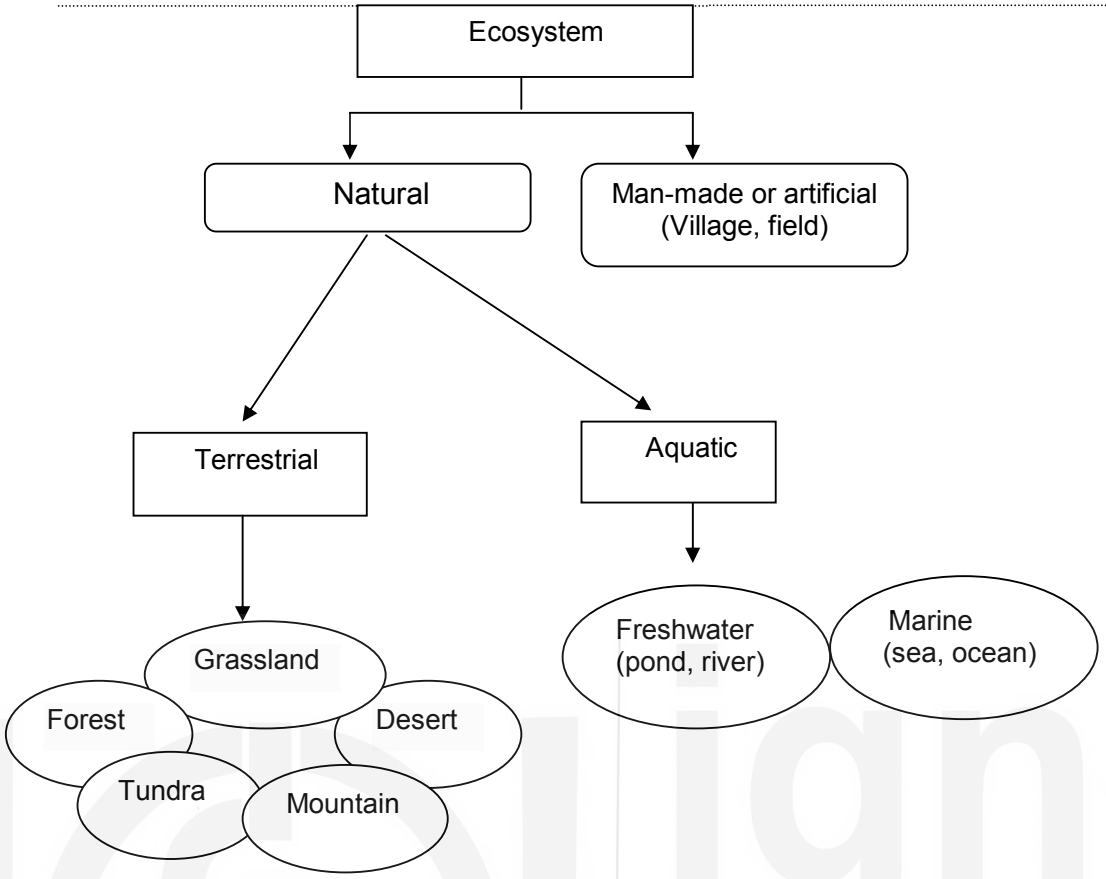


Fig. 1.9: Various types of ecosystems.

SAQ 4

Explain how heat energy trapped by plants is used by other organisms.

SAQ 5

Answer in one word:

1) The process of breakdown of complex organic matter

2) The organisms which are dependent upon producers for their food

3) Heat energy from the sun is trapped by

1.6.4 Population

A population is group of individuals of the same species present within a specific area at a particular time. It can also be defined as group of similar individuals of the same species capable of interbreeding among themselves. Growth, survival and movement/spread of population are regulated by various factors. Changes in the physical factors significantly alter the size of the population and affect the interactions between various populations.

Populations of the same species that can interbreed are referred as meta-populations.

The characteristics of population are represented by many attributes. These mainly include

1. Numerical attributes
2. Structural attributes

Numerical attributes

This includes parameters such as natality (birth rate), mortality (death rate), and density. These are given in figures.

Density- It is the number of individuals of a population present per unit area.

Natality (birth rate) – It is rate at which numbers of individuals are added to a population (by birth) over the specified time.

Mortality – Rate at which the individuals are lost form a population by death.

Dispersal- Rate at which individuals (of a population) move/migrate from an area.

Distribution- It is the total area of occurrence of a population.

Abundance- It is the number of individuals within a particular population.

Structural attributes

This includes parameters such as age, distribution, dispersion.

Population growth

Within any population, individuals are born and individuals die. If there are more individuals being born than dying, the population grows in size, while if more individuals are dying than being born, the population shrinks. Movement of individuals also affects the size of the population. Individuals enter or leave a population. This is referred as immigration and emigration.

The population size changes with time. The growth rate of population is calculated (given – delete) by the equation

$dN/dt = rN$

where 'r' is the intrinsic rate of natural increase in population. It is the difference between birth and death rate of the population.

N is the size of the population

The change in the size of the population is noted at time t.

The changes in population are explained by the exponential growth model. When resources are unlimited, populations exhibit exponential growth, resulting in a J-shaped curve. This means that size of population goes on increasing and after some time becomes constant. Maximum size of population that environment can sustain/support at a particular time is known

as carrying capacity. The growth rate of population slows down when it reaches the carrying capacity. When resources are limited, populations exhibit logistic growth. In logistic growth, population growth decreases as the resources get used (limited) and it levels off at carrying capacity resulting in an S-shaped curve (Fig 1.10).

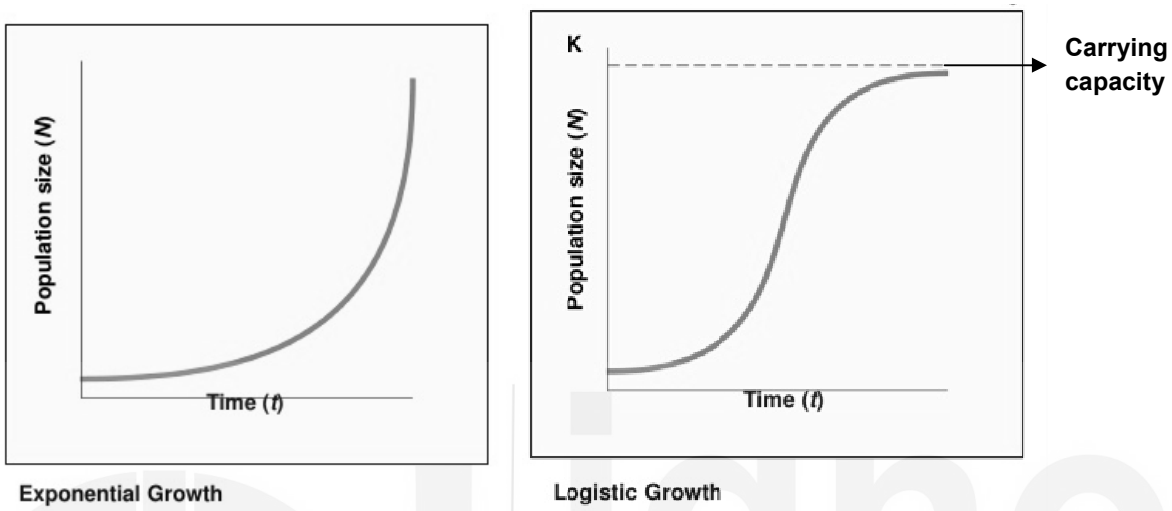


Fig. 1.10: J and S shaped population growth curve.

Other properties studied for population include measurement of dimensions such as population density, abundance or size. In a population, factors such as gender, age, developmental stage and size are considered as important. The rate of change of population growth and distribution of individuals is referred as study of dynamics. Biological and non-biological (environmental) factors influence population size. Biological factors include various types of interactions within the species. Environmental variables (non-biological factors) such as temperature, precipitation, disturbance, pollution, salinity, and pH also play an important role in regulating population size.

1.6.5 Community

(Community represents the population of species living and interacting in an area at a particular time. – delete) When several populations share a common habitat, resources and interact among themselves, they develop into a community (biocoenosis). Community is, therefore, an assemblage of populations of two or more species occupying the same geographical area at a particular time. All the organisms, microorganisms, plants and animals share a common habitat and interact among themselves. The organisms of a community usually exhibit feeding (trophic) relationships among themselves. Ecological communities can differ in terms of the types and numbers of species they contain. This is because environmental conditions influence the composition of a community to a great extent. For example- In Arctic zone communities, very few species are present while in some tropical rainforests, a large (huge – delete) number of species are present in a community.

Each community exhibits a number of characteristics such as diversity, density, dominance, composition and stratification. The transitional zone between two or more communities is called “ecotone”.

Community ecology or synecology includes the study of the interactions between species in communities on spatial and temporal scales. The parameters such as distribution, structure, abundance, demography and interactions between populations are considered. The properties such as species richness, productivity and succession are studied.

Structure of Community

In a community, the number of species and size of population varies. The community can be small having a single species or large comprising of several species. The structure of a community is the result of many interacting factors, both abiotic (non-living) and biotic (living organism-related). Community structure is influenced by many factors, including abiotic factors, species interactions, level of disturbance, and chance events. Environmental factors determine the characteristic of the community and pattern of organization of members in the community.

The organization of a biological community with respect to ecological interactions is referred to as community structure. A community's structure can be described by its **species richness and species diversity. Species richness** is the number of different species present in a community. Communities with the highest species richness are found in areas near the equator because of warm temperatures, plenty of rainfall and less seasonal variations. Communities with the lowest species richness lie near the poles because of cold, dry climate. Other factor that affects species-richness is the latitude. Species richness is generally highest in tropical latitudes but decreases significantly as we move towards the poles.

Dominance- In each community, few species are present in greater numbers. These are called dominant species. They modify the habitat and greatly influence the growth of other species present in the community to a great extent.

Diversity- It is the number of species (richness) and their occurrence or abundance (evenness). The greater is number of species and their distribution, more is the species diversity. Species diversity is measured in terms of number of different species in the community (species richness) and their relative abundances (species evenness). Larger numbers of species and more abundance of species lead to higher species diversity. Example - A forest community with 202020 different kinds of trees has greater species diversity than a forest community with only 555 kinds of trees.

Diversity is also related to the stability of the community. Communities with high species diversity are more stable. This is because many alternate pathways are available to enable the individuals to obtain energy and nutrients. In an area with high species diversity, if one of the species disappears, its function can be taken over by the other relatively close species.

Dependence- In a community there are some species which depend upon the dominant species for their survival. Example lower plants such as bryophytes/thallophytes are dependent on the shade and moisture conditions provided by dominant species.

In a community, processes such as energy flow and matter cycling take place. Energy flows via feeding relationships. The food energy gets transferred through different biotic components in a chain like manner referred to as the food chain. Food chains collectively form a food web. Solar energy absorbed by producers is converted to food and transferred to consumers. Functioning of an organism in an ecosystem is referred as 'ecological niche'.

The community dynamics change with time. This dynamic nature is reflected in the succession of organisms in a habitat. A series of changes results in the development of a relatively stable community, which maintains its structure in a particular area. Such a stable and mature community is called a climax community. The communities at various stages of succession are called seral communities. The community changes are gradual. The communities reach equilibrium and maintain a dynamic balance with the environmental changes in course of time. The process of change in communities and their environment at a place in the course of time is called "ecological succession".

Foundation and keystone species

Some species have strong impact on community structure and play a vital role in maintaining the balance of the community. These species include foundation and keystone species. A **foundation species** plays a unique, essential role in a community as it supports the other organisms. Kelps (brown algae) are foundation species that form the basis of the kelp forests in the sea at the coast of California. They create environments for survival of other organisms that make the forest community. The corals of a coral reef are another foundation species. The exoskeletons of living and dead coral make up most of the reef structure, which protects other species from waves and ocean currents.

A **species** that has a vast effect on community structure relative to their biomass or abundance is referred as a **keystone** species. A sharp reduction in diversity or collapse structure commonly occurs when this species is removed from the community. Keystone species belongs to higher trophic levels (top predators) and tends to modify their environment. The intertidal starfish *Pisaster ochraceus (sea star),* found in the northwestern United States, is an ideal example of a keystone species. If these are removed from the intertidal zone, populations of their prey (mussels) increase altering the species composition of the community greatly and reducing species diversity sharply. The mussel population expands and almost replaces the other species. When the sea stars are present, many species of barnacles and algae were found in the lower part of the intertidal zone. The loss of diversity occurred because mussels population increased removing the other species. The sea stars keep a check at the mussels population.

Interactions in a community

Living organisms show different types of interactions which can be harmful or beneficial to the organisms. These interactions are essential for the survival, growth, reproduction and continuance of the species. Species interact in different ways in a community. Interactions can be intraspecific i.e. between same species or inter-specific i.e. between different species. Intraspecific interactions include colonization, aggregation, while neutralism, competition and prey-predator relationships are interspecific. The other types of interactions reported in a community include
competition, predation, parasitism, mutualism, commensalism, etc.

Competition

Species present within a community compete with each other for resources. This is considered to be an important limiting factor of growth of population. The competition can be of two types

Interspecific – If competition occurs between the individuals of different species.

Intraspecific – If competition occurs between the individuals of same species.

Predation

It is the killing of an individual of another species for food. The predator species (an animal that kills and eats other animals) kills or harms the prey species (animals killed and eaten by other animals). Some predators kill their prey before eating them, while some other act as parasites and feed on prey when alive. Example - Feeding of herbivores on plants (grazing cow). Predation affects the population size of predators and prey.

Mutualism

It is a type of interaction in which both the species get benefitted. Example of such association is symbiosis. Symbiosis is a close, prolonged association between two or more different organisms of different species that benefit each other. Examples- *Rhizobium* bacteria growing in root nodules of legumes, insects pollinating the flowers of angiosperms.

Commensalism

A type of relationship among organisms in which one organism benefits while the other organism is neither benefited nor harmed. The organism that benefited is called the commensal while the other organism that is neither benefited nor harmed is called the host. Example, in epiphytes, trees support plants such as orchids which get benefitted but trees are not harmed. Opposite of commensalism is amensalism, an interspecific relationship in which a product of one organism has a negative effect on another organism.

Parasitism

Parasitism is an interaction in which one species lives on/inside the body of the other species (serving as a host) and depends upon it for its food requirements. The organism which is dependent is called as parasite.

Example- *Cuscuta* absorbs nutrients from the host plants through specialized structures called haustoria.

SAQ 6

Define the terms

- Biosphere
- Environment
- Population
- Species
- Carrying capacity

SAQ 7

Give differences between

1) Foundation and keystone species
2) Commensalism and amensalism
3) Prey and predator

SAQ 8

Answer in one word

1) J shaped graph for population growth represents.
2) S shaped graph for population growth represents.
3) The movement of population from one region to another.
4) High species diversity leads to.
5) Competition occurs between the individuals of different species.
6) The process of change in communities at one place in the course of time.

Classification of Communities

Depending on the conditions of their existence, plant communities have been divided into different groups.

Hydrophytic – plant communities living in water (aquatic habitats).

Mesophytic – plant communities living in moist soil habitat.

Xerophytic – plant communities living in dry or arid habitat.

Heliophytic – communities growing on conditions of abundant light.

Sciophytic – communities growing in shade.

Depending upon the location/habitat of their growth, they have also been designated as desert communities, mountain communities and estuarine communities.

1.7 SUMMARY

- Ecology is the study of relationships of living organisms and their environment.
- Ecology is interconnected with other disciplines of biology.
- Ecology has two main subdivisions- autoecology- study of individuals or populations of a single species with respect to their environment and synecology- study of interacting populations of different species.
- Environment or surroundings are composed of various living (biotic) and non-living (abiotic) factors that influences the organisms' growth and survival.
- The part of earth where life exists is referred as biosphere (ecosphere). It is composed of all living beings and elements of lithosphere, hydrosphere, and atmosphere.
- Population is the group of individuals of same species capable of interbreeding. The rate of population growth is characterized by attributes such as natality (birth date), mortality (death rate), density, abundance and dispersal. Depending upon the availability of resources, population growth can be exponential of logistic.
- Ecosystem- is the interaction of non-living (abiotic) and living (biotic) components with the environment. It can be natural or manmade.
- Community is the assemblage of several populations of different species present in a particular area. Community attributes consist of dominance, diversity, interactions and trophic structure.

References and text books

Begon, M., J. L. Harper and C. R. Townsend, 1990. Ecology - Individuals, Populations and Communities, Blackwell Scientific Publ., London, UK, 2nd edition.

Silvertown, J. 1982. Introduction to Plant Population Ecology. Longman, London, UK.

1.8 TERMINAL QUESTIONS

1. Answer in short

   a) Three components of biosphere

   b) Major attributes of population

c) Biotic and abiotic components of ecosystem

d) Various types of interactions in organisms of a community

2. List the major differences between

a) Producers and consumers

b) Natural and man-made environment

c) intraspecific and interspecific interactions

d) J and S shaped population curve

3. Outline the major divisions of ecology.

4. List in detail the abiotic components of the ecosystem.

5. Microbes form an important biotic component of ecosystem. Explain.

6. What do you understand by the term relative abundance?

1.9 ANSWERS

Self Assessment Questions

1. Many British and American ecologists have contributed a lot to evolution of modern day ecological concepts. Eugen Warming emphasized the role of abiotic factors (drought, fire, salt, cold) in the life of living organisms and introduced term 'adaptation' to explain species behavior under set of environmental conditions. H. C. Cowles (1869-1939) and F.E. Clements (1874-1945) published books on vegetation dynamics. Clements contributed lot to plant ecology and considered ecology as the science of community. He published series on phytogeography of North America. Sir Arthur Tansley (1914) is considered as the founder of British Ecological Society. He coined the term 'ecosystem', the interactive system established between the biocoenosis (the group of living organisms), and the environment in which they live. P. Odum (1971), Institute of Ecology, University of Georgia defined ecology as 'the study of structure and function of nature/environment or science of ecosystems. He contributed tremendously to modern ecology through books 'Fundamentals of Ecology', and 'Ecology and Basic Ecology'. R. Lindman made notable contributions to ecological energetics, productivity and ecological models associated with them.

2. a)

Autecology	**Synecology**
Study of individual species in relation to their environment	Study of a population or community in relation to their environment
Parameters such as geographical distribution, taxonomic position,	Parameters such as composition, behavior of communities in

morphological characters, reproduction, life cycle and behavior of species with reference to ecological factors or environment are studied.	relation to environment are studied.

b.

Aquatic Ecology	**Terrestrial Ecology**
Study of ecology of aquatic systems	Study of ecology of terrestrial systems
Includes fresh water ecology, estuarine ecology and marine ecology	Includes forest ecology, grassland ecology, cropland ecology and desert ecology

c.

Community Ecology	**Ecosystem Ecology**
It deals with structure and organization of a biological community with respect to environmental interactions.	It is the study of living organisms i.e. animals, plants and microbes along with the abiotic components of their environment (water, air and soil).
Factors such as structure, biodiversity, distribution and abundance of species are studied.	The aspects such as nutrient and energy flows are studied.
Various types of interactions such as predation, herbivory, competition and parasitism and mutualism are considered.	Food chain, food web, ecological pyramids and trophic levels are considered.

3. **Environment consist of two components-**Living or biotic and non-living or abiotic.

   Biotic components- All the living components are referred as biotic components. They Include plants, animals and microorganisms

   Abiotic components – All non-living factors are called as abiotic components. These include water, air, soil/land, and physical factors such as light and temperature.

4. In an ecosystem, plants harvest energy from the sun through the process called photosynthesis. Hence are referred as primary producers. Other living organisms (consumers- both herbivores and carnivores) feed on plants and energy gets transferred to them. These organisms are called consumers. Energy gets transferred to fungi and bacteria via death/decay and decomposition process. Hence in an ecosystem, a continuous flow of nutrients and energy occurs.

5.

1) The organisms which are dependent upon producers for their food- consumers (herbivores, carnivores).

2) Heat energy from the sun is trapped by –producers (green plants).

6.

- Biosphere - The part/zone/layer of earth where life exists is referred as biosphere (ecosphere). It is the global ecological system composed of all living beings and elements of lithosphere, hydrosphere, and atmosphere.
- Population - A population is group of all of the individuals of the same species present within a specific area. It can also be defined as collection of individuals of the same species present together in a particular space and time.
- Species - Species is the group of similar individuals capable of interbreeding among themselves.
- Environment - The total of all of the surroundings – air, water, land , vegetation that influence the existence of living beings is referred to as environment.
- Carrying capacity -Maximum population size that the environment can sustain at a particular time is called carrying capacity.

7. a). Prey and predator

Foundation species	**Keystone species**
A **species** that plays an essential role in a community as it supports the other organisms.	A **species** that has a vast effect on community structure relative to their biomass or abundance.
Example- Kelp (brown algae) is a foundation species that creates environments that allow the survival of organisms that make up forest community.	Example- The intertidal sea star *Pisaster ochraceus*, found in the northwestern United States.
Species can be of any trophic level and does not seem to influence environmental conditions.	Species belongs to higher trophic levels (top predators), and tends to modify the environment.

b).

Commensalism	**Amensalism**
A type of interaction in which one organism benefits while the other organism is neither benefited nor harmed.	A type of interaction in which product of one organism has a negative effect on another organism.

The organism that is benefited is called the commensal while the other organism that is neither benefited nor harmed is called the host.	A larger or stronger organism excludes a smaller or weaker because of deprivation of food. The chemical secretion from organisms damage or kill the other organism.
Example, an epiphytic orchid attached to the tree for support benefits the orchid but neither harms nor benefits the tree.	Example- secretion penicillin from *Penicillium* kills bacteria. Juglone secreted by *Juglans nigra* destroys many herbaceous plants within its root zone.

c).

Prey	**Predator**
Animals that are killed and eaten by other animals.	An animal that kills the prey
Organism is harmed/killed in the process.	Organism gets benefitted

8.

a) J shaped graph for population growth represents-exponential growth.

b) S shaped graph for population growth represents-logistic growth.

c) The movement of population from one region to another-migration

d) High number of species - species richness or diversity.

e) Competition occurs between the individuals of different species-intraspecific competition.

f) The process of change in communities at one place in the course of time- succession.

Terminal questions

1.

a) Three components of biosphere – mainly three components. These are hydrosphere, lithosphere and atmosphere

Hydrosphere (water) – It is the layer of water present on earth and includes water resources such as oceans, seas, rivers, lakes, streams, ponds, glaciers, polar ice caps and ground water.

Lithosphere (Land) - It is the solid component or the hard surface (crust) of earth. It consists of three layers: crust, mantle and core. The uppermost part consists of weathered rocks, minerals and organic matter and is known as soil.

Atmosphere (air) - It is layer of gases surrounding the earth and consists of a complex mixture of gases, water vapor and particulate matter.

b) Major attributes of population-

Population is represented by many attributes. These mainly include

Numerical attributes- These include parameters such as natality (birth rate), mortality (death rate), density (number of individuals of a population per unit area). These are given in figures.

Structural attributes – This include parameters such as age, distribution (area covered by a population), dispersion (Rate at which individuals move from a population) and abundance (number of individuals within a population).

c) Biotic and abiotic components of ecosystem

Biotic – Living components of ecosystem. Includes plants (producers), animals (consumers), microbes (decomposers)

Abiotic – Non-living components of ecosystem. Include soil, physical factors such as temperature, light.

d) Various types of interactions in organisms of a community

Intraspecific – Interactions occurring within the population of same species

Interspecific - Interactions occurring within different species.

Some positive and negative interactions such as parasitism, mutualism and symbiosis have also been reported among species.

2 a.

Producers	**Consumers**
They are also called as autotrophs, transducers or convertors.	They are also called as heterotrophs.
They convert energy obtained from sun into food. They include photosynthetic organisms.	They are heterotrophic organisms that eat food produced by autotrophs.
In terrestrial ecosystems, producers are green plants. In the aquatic ecosystems, the floating plants called phytoplankton and rooted plants called macrophytes are the producers. Algae are the	Herbivores (primary consumers) eat plants, while carnivores (secondary or macroconsumers) eat animals. Quaternary consumers or tertiary carnivores include organisms that feed on secondary carnivores. Omnivores

dominant producers in freshwater and marine ecosystems.	include humans that feed on both plants and animals.

b.

Natural ecosystems	**Man made or artificial ecosystems**
Created naturally	Created by man by altering natural conditions
Examples- Mountains, lakes	Examples- cultivated fields, cities, townships

c.

Interspecific	**Intraspecific**
If competition occurs between the individuals of different species.	If competition occurs between the individuals of same species.

d.

J shaped curve	**S-shaped curve**
When resources are unlimited, populations exhibit exponential growth	When resources are limited, populations exhibit logistic growth.
Size of population goes on increasing and after some time becomes constant.	Population growth decreases as the resources are limited.
Exponential growth	Logistic growth

3. Ecology

Ecology has been divided into two types

Autecology is the study of individual species in relation to their environment. The geographical distribution, taxonomic position, morphological characters, reproduction, life cycle and behavior of species are studied in reference to the environment.

Synecology is the study of a population or community in relation to their environment. The composition and behavior of plant communities and their relationship to the environment are studied.

Apart from these ecological studies have also been divided into many other types such as organism, population, community and habitat ecology depending upon the component of ecology studied.

4. These include the non-living or physico-chemical factors. They support the biotic components. They restrict growth, number, and diversity of population of a species, hence are called as limiting factors. These factors mainly include

   Climatic factors – Include physical factors such as light, temperature, wind, humidity.

   Edaphic factors- Include soil and its structure. Chemical and physical properties like the soil type, soil profile, organic matter, minerals, soil water, and soil organisms are included in it.

   Physical factors – Includes water, air.

   Materials – Includes inorganic components such as carbon, sulphur, nitrogen, phosphorus etc. All these elements get cycled (biogeochemical cycles) via different components of ecosystem. The organic components of an ecosystem are proteins, carbohydrates, lipids and amino acids. These are synthesized by biota (flora and fauna) of an ecosystem.

5. Microbes represent the major group of organisms involved in decomposition of organic matter. They include bacteria and fungi. They are referred as decomposers/saprotrophs or reducers. Decomposers break down organic matter into inorganic matter via secretion of digestive enzymes. In an ecosystem they play an important role because they recycle nutrients from decaying organic material. They help in the process of mineralization which builds up organic matter (an essential component of soil).

6. In a community many species are present in abundance while some are rarely present. The species present in large number can be counted and represent abundance. The relative proportion of different species in a community is referred as relative abundance.