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ECOLOGY & ENVIRONMENT

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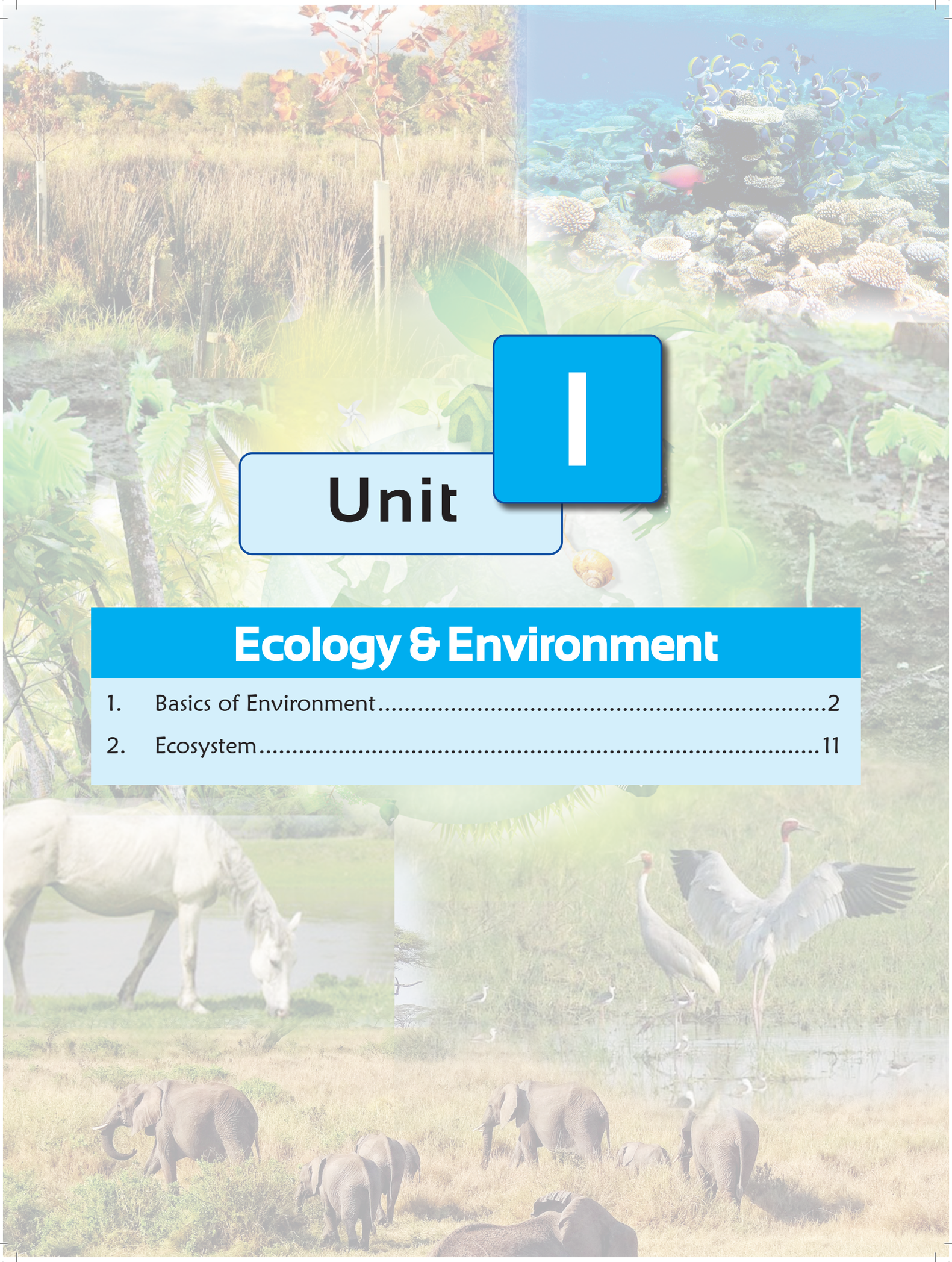


Unit I

Ecology & Environment

CHAPTER

1

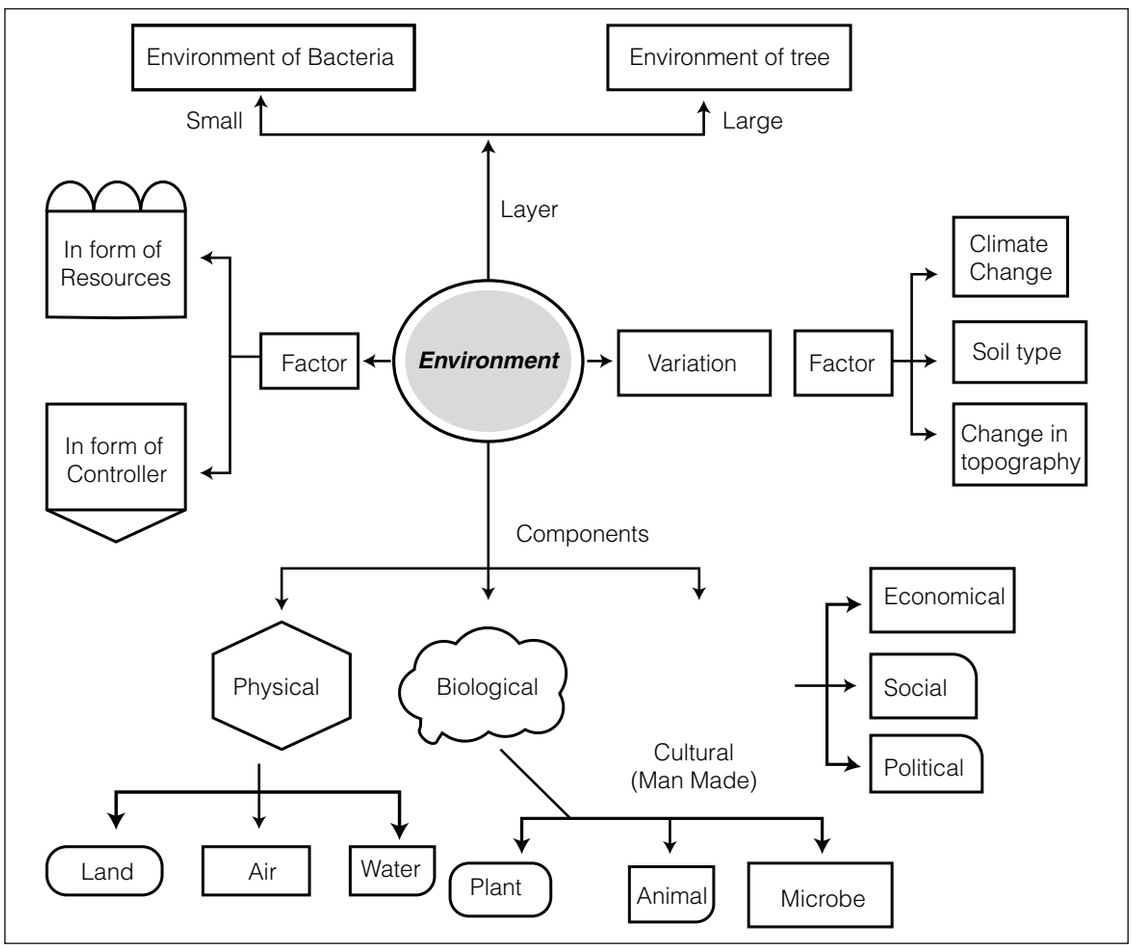
BASICS OF ENVIRONMENT

1.1 Introduction

The word environment is derived from the French word "*Environer / Environner*" which refers to the neighborhood. It is the sum total of conditions that surround us at a given point in time and space. Each part of the environment is called ecological factor. The environment can be biotic (living) or abiotic (physical or non-living). It influences the growth and development of living forms.

COMPONENTS OF ENVIRONMENT	
Abiotic	**Biotic**
Light	Human beings
Temperature	Animals
Soil	Green & Non-green Plants
Atmospheric gases	Decomposers
Weather	Parasites
	Bacteria
	Fungi
	Protozoa

Environment regulates the life of the organisms including human beings. Human beings interact with the environment more vigorously than any other living beings. Ordinarily, environment refers to the materials and forces that surround the living organism. It provides us with all the resources for leading a comfortable life.



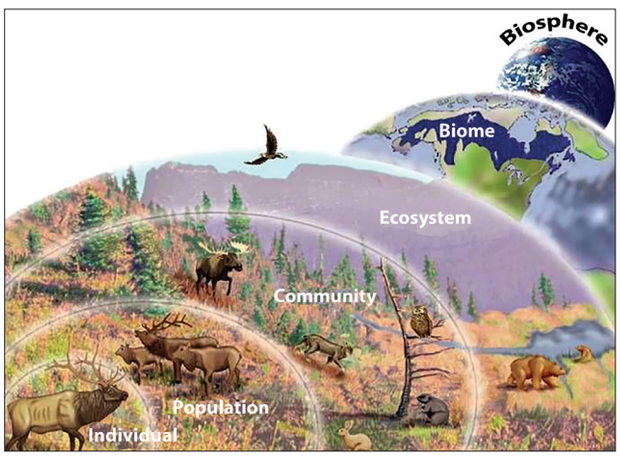
Ecology may be defined as the scientific study of the relationship of living organisms with each other and with their environment. ***The term ecology was first coined in 1869 by the German biologist Ernst Haeckel***. It has been derived from two Greek words, '*oikos*', meaning home or estate and 'logos' meaning study. The emphasis is on relationships between organisms and the components of the environment namely abiotic (non-living) and biotic (living).

Environment is the surrounding in which the organisms live whereas the ecosystem involves the interaction between the environment and the organisms living in it.

1.2 Levels of Ecological Organization

Individual

An individual is any living thing or organism. Normally, individuals do not breed with individuals from other groups. The individuals perform all of the life processes independently. ***For Example***, The Tiger (Panthera tigris) is a type of an individual organism; The Royal Bengal Tiger (Panthera tigris tigris) is a species of tiger among others like the Sumatran tiger. (Panthera tigris sumatrae) etc. Similarly, The Elephant is an Individual type of organism. Among them, the African elephant (Loxodonta africana), Asian Elephant (Elephas maximus) are different species.



Population

The population is a ***group of individuals belonging to the same species***. They are found in a particular geographical area of varying scales and sizes. Every individual species are represented in populations. The populations of Royal Bengal Tiger can be seen in Sundarbans etc. whereas Sumatran tigers can be seen in Pacific islands of Sumatra.

Community

It is a naturally occurring assemblage of species population which occurred together in specific geographical space and time. These individuals interact with one of the same species as well as with the other species.

Types of Communities

On the basis of size and degree of relative independence, communities may be divided into two types:

- **Major Communities:** A major community is the smallest ecological unit which is able to sustain itself and is self-regulating. These are large sized and relatively independent of other communities. They depend only on the sun's energy from outside. A major community is a combination of floral community, faunal community and a microbial community. For Example, a pond, a forest, a grassland or lake.
- **Minor Communities:** Minor communities are smaller ecological units that are not individually self-sustaining and rely on interactions with other communities. They make up major communities and are dependent on neighboring communities for their energy and nutrients.

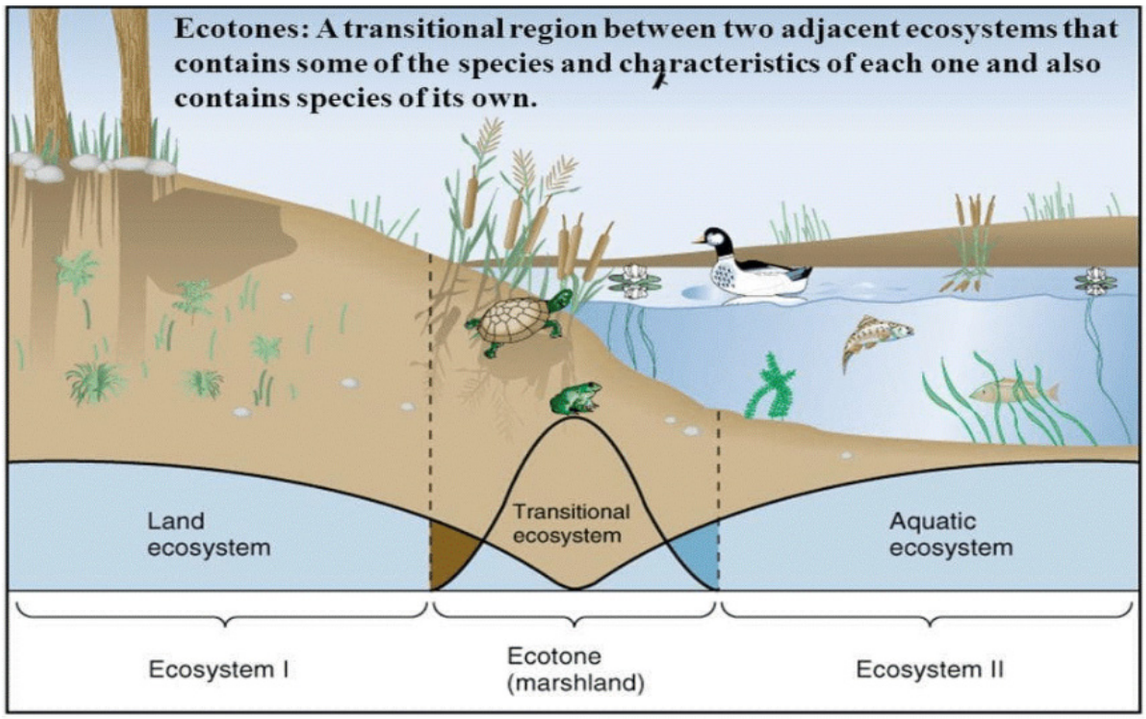
Structure of a Community

Communities may be small, consisting of a limited number of species in a small space, or large, comprising several species populations in a large area. Community structure is the composition of a community, including the number of species in that community and their relative numbers. Different factors like climatic patterns, interactions between organisms, the density of species, the frequency of disturbances and abundance of species influence the structure of a community.

Characteristics of a Community

In a community, the number of the species and size of their population vary greatly. The environmental factors determine the characteristic of the community and its pattern. The features within communities are highly variable. Some of the prominent features are as follows:

- **Dominance:** At each trophic level, one or two species exert more dominance over the function and structure of the community.
- These dominant species impact on the population and activities of other organisms, thus affecting the nature of the community.
- The ecological dominants may change the abiotic conditions of a habitat over a period of time.



- However, all the species are important for the balanced functioning of the community. *For example:* In a forest, though a dominant tree species may control the availability of light to other plants, the temperature in the lower canopy, and the availability of nutrients to other organisms, their reproduction may depend on pollination by a rare insect.
- **Interdependence:** In a community, plants, animals and microbes have a fundamental dependence on at least one organism, although most organisms will engage in multiple interactions. These interactions can be nutritional, reproductive or protective.
- **Stratification:** Communities usually display some form of stratification, by which the populations that make up the community are distributed into defined horizontal or vertical strata. Some organisms may occupy more than one stratum, moving between the layers often on a diurnal basis. *For example*, a bird that feeds on the forest floor during the day but roosts within the canopy.
- **Diversity:** It is the variation in the ecosystem of the region or over the whole planet. It considers both the number of species in the community and their relative abundance. Communities with high species diversity have been found to be comparatively more stable.
- **Ecotone:** Communities occur in a range of different sizes, and the boundaries of each are often not well defined. An ecotone is a transitional area between two biomes, where communities meet and integrate. Ecotones are considered areas of great environmental importance. They provide an area for a large number of species, they often experience influx from animals looking to nest or searching for food.

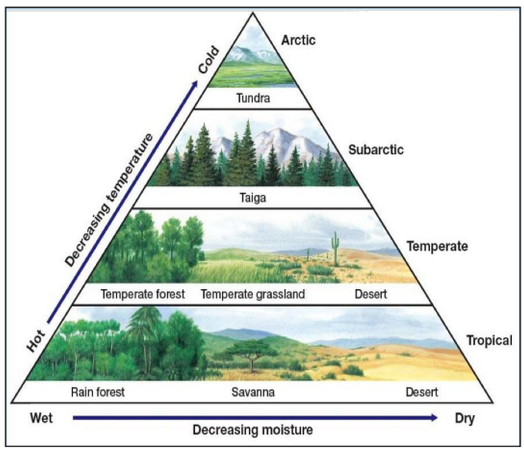
Ecosystem

An ecosystem is a community of plants and animals interacting with each other in a given area, and also with the abiotic components of the environment such as air, water, sun and soil. The ecosystem relates to the way that all these different organisms live and interact with each other. It is a place like a forest, Taiga, Grassland, desert, coral reefs, stillwater, or a river stream. (Note: Ecosystem has been dealt in detail in the next Chapter)

Biome

- Biomes are very large ecological units characterized by a major vegetation type and associated fauna adapting to a specific climate zone.
- A Biome is not an ecosystem, but it can be seen as a form of a massive ecosystem.
- The boundaries and abundance of organisms in a biome is often defined by abiotic factors such as climate, relief, geology, soil and vegetation.
- Many units of an ecosystem may be found in one biome. Moreover, no two biomes are alike.
- Biomes play a crucial role in sustaining life on earth. *For example*, the Aquatic biome is home to millions of fish species and the source of the water cycle. It also plays a very important role in climate formation.

- The terrestrial biomes provide foods, enrich the air with oxygen and absorb carbon dioxide and other harmful gases from the air. They also help regulate climate.



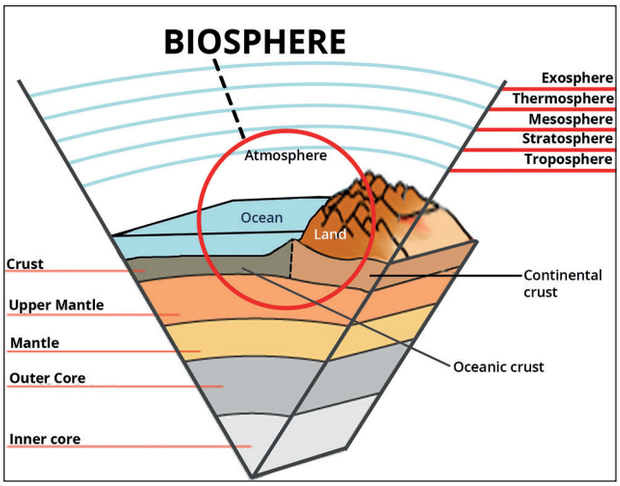
Variants in Biomes

There are five major variants of biomes on earth. In these five, there are many sub-biomes, under which there are many more well-defined ecosystems.

- **Desert Biomes:** They are the Hot and Dry Deserts, Semi-Arid Deserts, Coastal Deserts and Cold Deserts.
- **Aquatic Biomes:** Aquatic biomes are grouped into two categories i.e. Freshwater Biomes (lakes, ponds, wetlands, rivers and streams) and Marine Biomes (oceans, coral reefs and estuaries).
- **Forest Biomes:** There are three main biomes that makeup Forest Biomes. These are the Tropical Rainforest, Temperate and Boreal Forests (also called as Taiga). Example: Amazon biome contains moist tropical rainforest.
- **Grassland Biomes:** There are two main types of grassland biomes: the Savanna Grasslands and the Temperate Grasslands. Example: African Savanna and Prairies.
- **Tundra Biomes:** There are two major tundra biomes – The Arctic Tundra and The Alpine Tundra.

Biosphere

- The biosphere is made up of parts of the earth where life exists.
- The biosphere refers to the realm of living organisms and their interactions with the environment i.e. atmosphere, hydrosphere and lithosphere. It contains all life forms on earth.
- It is that part of the earth in which many smaller ecosystems exist and operate. It extends from the deepest root systems of trees to the dark environment of ocean trenches, to lush green rainforests and high mountain tops.



However, living organisms are mostly confined to the areas that receive solar radiation which includes the atmosphere, the land surface, upper layers of soil and the upper region of water bodies. In the ocean, the biosphere does not end where light ceases and goes a little further as gravity enables the energy flow to continue downward.

Similar to the existence of underwater biosphere, it extends upwards in the atmosphere to a certain limit. On high mountains, like the Himalayas, the limit above which chlorophyll bearing plants cease to exist is around 6.2 km.

Division of Biosphere

The biosphere is made up of three parts, called the *lithosphere, atmosphere and hydrosphere*. They have been described as follows:

Atmosphere

The term 'atmosphere' refers to the layer of gases, commonly known as air, which surrounds the earth. It is one of the necessary conditions for the existence of life.

Hydrosphere

Water is a vital component for all forms of life that exist on the surface of the earth. This water component of the earth is called hydrosphere. The Hydrosphere includes the oceans, seas, lakes, ponds, rivers and streams. It covers about 70% of the surface of the Earth.

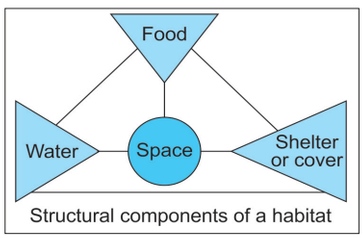
Lithosphere

Lithosphere is the rigid outermost shell or the hard top layer of the earth. It is made up of rocks and minerals and covered by a thin layer of soil. It is an irregular surface with various landforms such as mountains, plateaus, plains and valleys. The lithosphere is broken up into large and small plates. The lithosphere is of two types- Oceanic Lithosphere (associated with oceanic crust) and Continental Lithosphere (associated with continental crust).

1.3 Habitat

Habitat is the physical environment in which an organism lives. Each organism has particular requirements for its survival and lives where the environment provides for those needs. For example, the habitat of an elephant would be a forest, habitat of a tapeworm is the human gut. Forests, oceans, rivers, etc. are habitats of various organisms.

Earth has four major habitats: Terrestrial, Freshwater, Estuarine and Ocean.



Structural components of a habitat

The features of the habitat can be represented by its structural components namely: space, food, water and shelter or cover.

1.4 Niche

Each organism plays a particular role in its ecosystem.

- A niche is defined as the role a species plays in the ecosystem. ***The functional characteristics of a species in its habitat are referred to as niche in that common habitat***. The habitat of a species is like its address, whereas niche can be basically thought of as its ecological role or profession.
- The term 'niche' means the sum of all the activities and relationships of a species by which it uses the resources in its habitat for its survival and reproduction.
- A niche is **unique for a species** while many species share the habitat. ***No two species in a habitat can have the same niche***. This is because if two species occupy the same niche they will compete with one another until one is displaced. Once a niche is left vacant, other organisms can fill that position.

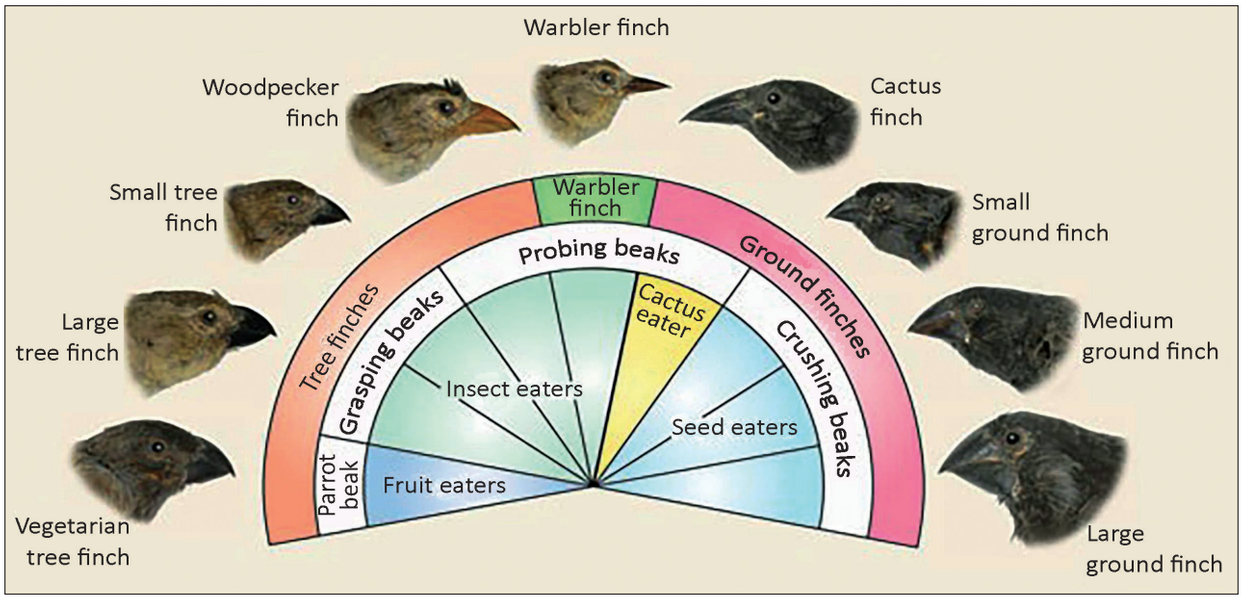
HABITAT AND NICHE: A COMPARISON

Dimensions	Habitat	Niche
Definition	A Habitat is a place or part of an ecosystem where a species live and interact with other factors.	Niche is a role of an organism within its environment or ecosystem.
Nature	Habitat is a physical place.	Niche is an activity performed by organisms.
Characteristics	It reflects the living place of an organism.	It is about biotic and abiotic association within the environment in terms of its diet, reproduction and relationships with other species.
Support	Habitat supports numerous species at a time.	Niche supports a single species at a time.
Specificity	Habitat is not species specific.	Niche is species specific.
Relation	It is a superset.	It is a part of habitat. In short, it is a sub-set of habitat.
Association	Species with different niche may live in a habitat.	There may be competition from other species for the same niche.
Examples	• Deserts • Oceans • Forest • Rivers • Mountains	Honeybees that gather nectar from flowers to make honey. Other organisms existing in the same environment don't do it. For example, a bird may live on the same tree as a beehive, but they don't make honeys as a beehive does.

1.5 Adaptation

Every organism is suited to live in its particular habitat. An adaptation is thus, the structural, physiological or behavioral characteristic of the life of an organism that enables it to survive in a particular environment. Examples of basic adaptations that help animals and plants to survive in their respective environments are as under:

- The shape of bird's beak.
- The thickness or thinness of fur.
- Presence of feathers and wings in birds.
- Evergreen and deciduous nature of trees.
- Presence and absence of thorns on leaves and stems.
- Presence of gills and fins in fishes.



1.6 Species

A species is defined as; "a group of similar populations of organisms whose members are **capable of interbreeding**, and to **produce fertile offspring** (children)". A tiger, a lion, a lotus and a rose are examples of different species. Every species has its own set of genetic characteristics that make the species unique and different from other species.

Species Formation

Speciation

The number of species surviving in the world today is the outcome of two processes speciation and extinction. Speciation is the process by which a new plant or animal species is formed. Speciation occurs when a group within a species separates from other members of its species and develops its own unique characteristics. The process of evolution is the mechanism by which speciation is brought about.

A species comprises of many populations. Often different populations of a species remain isolated due to some geographic barrier such as mountain, ocean, river, etc. Geographic isolation occurs when a physical barrier develops between two populations of a species. The most common way a population undergoes speciation is by geographic isolation.

Natural Selection

Natural selection is the process through which populations of living organisms adapt and change. Individuals in a population are naturally variable, meaning that they are all different in some ways. The organisms better adapted to their environment tend to survive and reproduce more than those less adapted to their environment. This variation means that some individuals have traits better suited to the environment than others.

Isolation

- **Geographical Isolation:** The members of a population of a species live in a particular environment and are capable of breeding with the member of another population of the same species.
- **Ecological Isolation:** It is caused by differences in temperature, humidity, pH, etc. in the environment of the two populations.
- **Reproductive Isolation:** It is caused by interference in interbreeding between members of different populations of species.

Mutation

It is sudden change in genetic makup of an organism which becomes the potent factor for speciation.

It take place randomly in isolated populations giving rise to new variations within each sub-population of these mutations. The variations that help to adapt to the environment are reproduced in greater numbers in the next generation due to natural selection.

Genetic Drift

It describes random fluctuations in the numbers of gene variants in a population. Genetic drift takes place when the occurrence of variant forms of a gene, called alleles, increases and decreases by chance over a time. These variations in the presence of alleles are measured as changes in allele frequencies.

Hybridization

It occurs when two divergent lineages (e.g. species) with independent evolutionary histories come into contact and interbreed. Hybridization can result in speciation when hybrid populations become isolated from the parental lineages, leading to divergence from the parent populations.

Polyploidy

It is the heritable condition of possessing more than two complete sets of chromosomes. Polyploids are common among plants, as well as among certain groups of fish and amphibians. For instance, some salamanders, frogs and leeches are polyploids.

Recombination-Speciation

It can be viewed as the evolution of restrictions on the freedom of genetic recombination: new combinations of alleles can be generated within species, but alleles from different species cannot be brought together.

Extinction

Extinction occurs when species cannot evolve fast enough to cope with the changes taking place in their environment.

Many species have gone extinct during geological history of the earth.

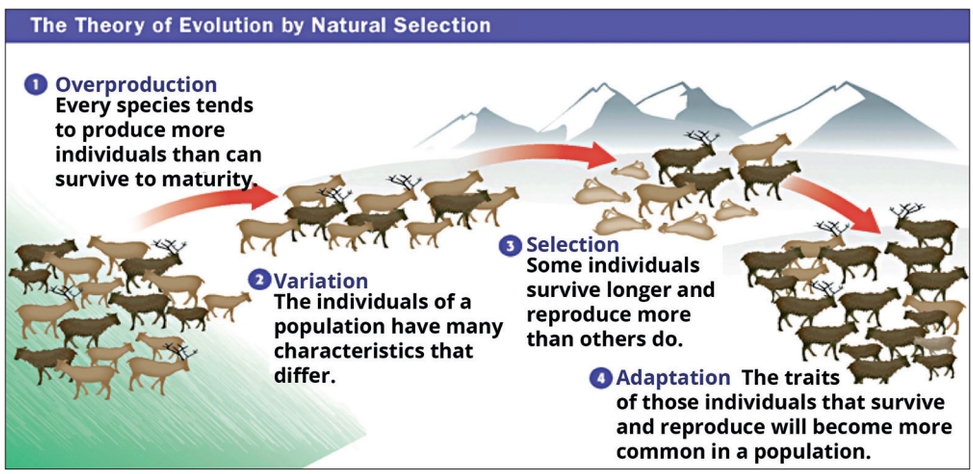
Extinction may take place due to catastrophic natural phenomena such as tsunami, volcanoes etc. In recent times, human activities such as deforestation, over exploitation, environmental pollution and environmental change are other factors responsible for extinction.

Intraspecies Variation

The difference in colour of skin, types of hair, eye colour, blood type among different ethnic groups represent variation within human species. Similarly, different shapes and sizes of plants and animals are examples of variation within each organism. For Example, In plants, different varieties of various shape and size exhibit variation among the same plant species. Competition and natural selection determine as to which variation will help the organism succeed and survive. Those variations that enable a species to survive in the struggle for existence are encouraged and promoted.

Evolution

A valid theory of evolution was propounded by *Charles Darwin* and Alfred Wallace in 1859. This theory has been extended in the light of progress in genetics and is known as Neo-Darwinism.



1.7 Population

The population is defined as a group of freely interbreeding individuals of the same species present in a specific area at a given time. For example, when we say that the population of a city is 50,000, we mean that there are 50,000 humans in that city. However, all populations of humans living in any part of the world constitute the species Homo sapiens.

Factors for Population Growth

The characteristics of any population depends on:

- Density of the population
- Natality (birth rate)
- Mortality (death rate)
- Dispersal
- Biotic potential
- Age distribution.

Density of the Population

The number of individuals per unit area at a given time is termed as population density. For example, you may notice more plant and animal species in the garden.

Natality (Birth Rate)

The rate at which new individuals are born and added to a population under given environmental conditions is called natality.

Mortality (Death Rate)

Loss of individuals from a population due to death under given environmental conditions is called mortality. The number of individuals dead in a year is calculated for obtaining the mortality rate or death rate.

Dispersal

The movement of individuals of a population out of a region on a permanent basis is termed emigration while immigration refers to the movement of individuals into a new area where dispersal includes both emigration and immigration of individuals.

Biotic Potential

Biotic potential refers to the maximum reproductive capacity of an organism under optimum environmental conditions. It is often expressed as a proportional or percentage increase per year. Full expression of the biotic potential of an organism is restricted by environmental resistance i.e. any factor that inhibits the increase in number of the population.

Age Distribution

Natural populations include individuals of all age groups. It, therefore, becomes necessary for us to consider age distribution of a population. Age distribution refers to the proportions of individuals of different age groups in a population.

A rapidly growing population will usually contain a large proportion of individuals in the reproductive age group; a stationary population (where there is no increase or decrease in population) contains an even distribution of all age groups, and a declining population contains a large proportion of old or post-reproductive age of an individuals.

Life History Variation

Under a particular set of selection pressures, organisms evolve towards the most efficient reproductive strategy. Populations evolve to maximise their reproductive fitness, also called Darwinian fitness, in the habitat in which they live.

Ecologists suggest that life history traits of organisms have evolved in relation to the constraints imposed by the abiotic and biotic components of the habitat in which they live. Evolution of life history traits in different species is currently an important area of research.

Population Interactions

The biological community of an area or ecosystem is a complex network of interactions. The interaction that occurs among different individuals of the same species is called intraspecific interaction while the interaction among individuals of different species in a community is termed as interspecific interaction.

INTERSPECIFIC COMPETITION	INTRASPECIFIC COMPETITION
A form of competition between different species inhabiting the same ecological area.	Competition for resources between members of the same species.
Competition is between members of different species.	Competition is between the members of the same species.
Occurs between individuals with different adaptations.	Occurs between individuals with similar adaptations.
Occurs for a specific requirement.	Occurs for all types of requirements of the species.
Either both or one species can be suppressed due to the competition.	Directly affects the population size and composition.
Effect is not much severe.	Effect is much severe.

Types of Interactions

Positive Interactions

- **Commensalism:** In this relationship one of the species benefits while the other is neither harmed nor benefited. Some species obtain the benefit of shelter or transport from another species. For example sucker fish, remora often attaches to a shark by means of its sucker which is present on the top side of its head. This helps the remora get protection, a free ride as well as meal from the left over of the shark's meal.
- **Mutualism:** This is a close association between two species in which both the species benefit. For example, honey bees and flowers are in a mutual relationship, where in honey bees benefit through collecting nectar and for the flower, the bees help in pollination. However, some mutualisms are so intimate that the interacting species cannot live without each other. Such close associations are called symbiosis. Example: corals and zooxanthellae are in mutual relationship.

Neutral Interactions

Neutralism: Neutralism describes the relationship between two species which do interact but do not affect each other. It is to describe interactions where the fitness of one species has absolutely no effect what so ever on that of other. Example : interaction between a rainbow trout and dandelion in a mountain valley or cacti and tarantulas living in the desert.

Negative Interactions

- **Amensalism:** This is a negative association between two species in which one species harms or restricts the other species without itself being adversely affected

or harmed by the other species. Example : Juglone secreted from the roots of black walnut destroying its surrounding plants and development of wheat hindered by Convolvulus arvensis.

- **Predation:** In this type of interaction predator captures, kills and eats an animal of another species called the prey. The predator naturally benefits from this relationship; while the prey is harmed. Example: owls hunting mice, or shrews hunting worms and insects.
- **Parasitism:** In this type of interaction, one species is harmed and the other benefits. Parasitism involves parasite usually a small size organism living in or on another living species called the host from which the parasite gets its nourishment and often shelter. The parasite is benefited and the host is harmed. The roundworm, tapeworm, malarial parasites, many bacterial, fungi and viruses are common parasites of human.
- **Competition**: This is an interaction between two populations in which both species are harmed to some extent. Competition occurs when two populations or species, both need a vital resource that is in short supply. Example : Plants compete with each other for light exposure, temperature, humidity, pollinators, soil nutrients and growing space.

ANTIBIOSIS

It is the complete or partial inhibition or death of one organism by another through the production of some substance or environmental conditions as a result of metabolic pathways. Here, none of them derives any benefit. These substances and/or conditions are harmful to other organisms. The phenomenon of antibiosis is more common among the microbial world. For Example: Pond blooms of blue-green algae especially microcystis are known to produce toxins such as hydroxylamine which causes death of fish and cattle.

TYPE OF INTERACTION	SPECIES 1	SPECIES 2	EFFECTS OF INTERACTION
Positive Interactions			
Mutualism	+	+	Interaction is favourable to both species.
Commensalism	+	0	One species (the commensal) benefits while the other species (the host) neither harmed nor inhibited.
Neutral Interactions			
Neutralism	0	0	Both species remain unaffected.
Negative Interactions			
Parasitism	+	–	Beneficial to one species (parasite) and harmful to the other species (host).
Predation	+	–	Predator-prey relationship: one species (predator) benefits while the second species (prey) is harmed and inhibited.
Amensalism	–	0	One species is inhibited while the other species is unaffected.
Competition	–	–	Adversely affects both species.
+ means Beneficial; – means Harmful; 0 means Unaffected or Neutral			

■■■■

TRY THIS PRELIMS PREVIOUS YEAR QUESTION

1. The vegetation of savannah consists of grassland with scattered small trees, but extensive areas have no trees. The forest development in such areas is generally kept in check by one or more or a combination of some conditions.

Which of the following are such conditions?

1. Burrowing animals and termites
2. Fire
3. Grazing herbivores
4. Seasonal rainfall
5. Soil properties

Select the correct answer using the code given below.

(a) 1 and 2 (b) 4 and 5
(c) 2, 3 and 4 (d) 1, 3 and 5

(2021)

Ans. (c)