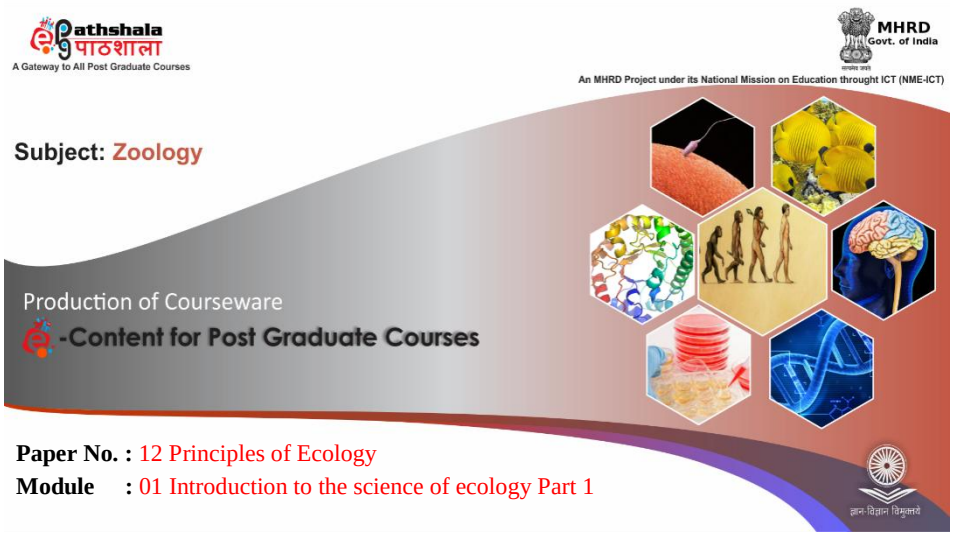

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Description of Module	
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1. Learning outcomes

After reading this chapter you will be able to:

- Define and explain the basic concept of ecology and its structure.
- Properties and function to maintain the stability in order to act positively towards the environment.
- To study the ecological hierarchy.
- Differences between synecology and autoecology.
- Concept of ecosystem and various types of habitats.

2. Introduction

Ecology is the branch of biology that deals with the relationships of organisms to one another and to their physical surroundings or immediate environment. It deals with the interactions between organisms and their natural habitats. We (humans) are also a part of the ecosystem and dependent on it for our survival because we too are after all just one more species on this planet earth.

The term ecology ("**Ökologie")** was coined in 1866 by the German Zoologist, **Ernst Haeckel** (1834–1919). It was derived in 19th century from the Greek word "**Ökologie**" meaning: οἶκος, "house", or "environment"; **-logíe**, "study of". Ernst Haeckel gave the following statement originally in German language, which says;

"By occology we understand the science of economy of the domestic affairs of organisms. It enquires into the whole relation of animals with their inorganic and organic surroundings, and above all their friendly and hostile relations with such animals and plants as they come into directed or indirected contact with or in short with all the involved interdependence that Darwin designated as the condition of the struggle for existence".

Ecology is essentially an interdisciplinary field incorporating biology, geography and geoscience (earth science). Ecology means study of biota, its surrounding environment and their interactions amongst themselves as well as their physical surroundings. An organism's environment is made up of the living or biotic, and non-living or abiotic components

(Table 1). For instance; the study of food chains in wetlands, study of habitats in desserts, etc. This relationship could be between a particular organism with its environment or between human groups and their physical environment or between flora and fauna with their physical surroundings. Sometimes it's also referred to as **Bionomics.**

Abiotic Components	**Biotic Components**
Sunlight	Primary producers
Temperature	Herbivores
Precipitation	Carnivores
Water or moisture (Humidity)	Omnivores
Soil or water chemistry (e.g., P, NH_4+)	Detritivores
etc.	etc.

Table 1: Components of ecosystem
*All of these vary over space/time
(**Source:** Author)

Ecosystem emphasises on the importance of transfers of materials and/or energy between similar or different organisms and their environment. The term "**ecosystem**" was **coined** by British ecologist **Arthur Tansley**. A habitat is an ecological or environmental area that is inhabited by a particular species of animal, plant, or other types of organisms. It is made up of physical factors as well as biotic factors (Fig. 1). Example of a habitat could be any geographical area or even as small as inside an organism.

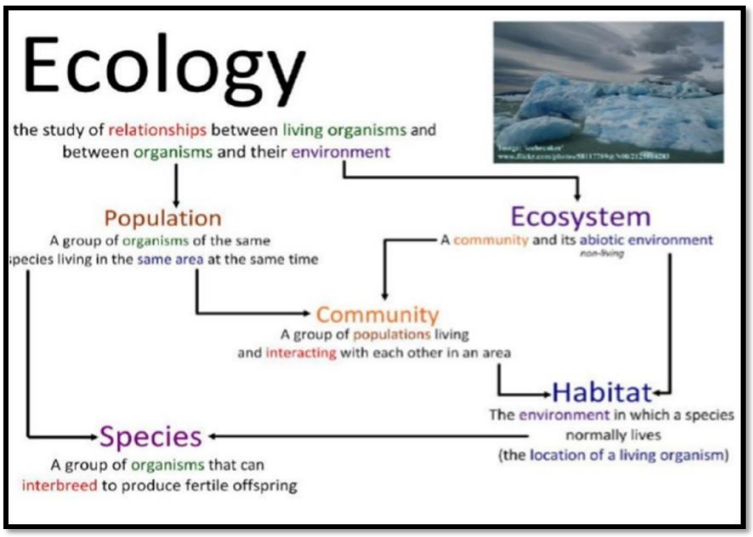

Fig. 1: Components of Ecology (**Source:** Author and Departmental Artist)

3. Historical perspectives

The genesis of ecology is very difficult to trace. Ancient Indian writing reflects the reference of ecological thoughts like Vedic, Epic, Puranic etc. describe the importance of Vayu (air), Jala (water), Desha (topography) and Kaal (time). The inter-relationships between the organisms and their environment are described by some outstanding Greek scholars like Aristotle, Hipocrates, Theophrastus etc. Some of the scientists with their important contributions are:

- **Baron A.V. Humbolt (1804)** explored the tropical and temperate South America and published 26 volumes based on the data collected by him.
- **Alfred R. Wallace** published three books titled (i) The Malaya Archipelago (ii) The geographical Distribution of Animals and (iii) Island Life.
- **Geaffroy St. Hilaire (1859)** first used term '**ethology'** to refer the study of relationship of organisms with their environment.
- **St. George Jackson Milvart** proposed the term **'Hexicology'** to refer the study of organisms with their relation to environment regarding the nature of locality, temperature and amount of light that best suit them and also their relation with other organisms as enemies, rivals or accidental and involuntary benefactors.
- **Rieter (1868)** first introduce the term **'Oekologie'** to describe the inter-relationship that exist between organisms and their environment**.**
- **Ernst Haeckel (1869)** was a German Biologist and was credited to have coined the term 'ecology' and used it widely in his literature. He also precisely gave its definition.
- **Le Coq Sendfner** and **Kerner** introduced for the first time the plant communities as an aspect of ecology.
- **Karl Mobius (1877)** described the Animal communities.
- **Schroeter** and **Kirchner (1896)** introduced the term 'synecology'.
- **Macfadyen (1957),** a British Biologist laid down the principles governing the relationship of plants and animals and their relations to environment.
- **K. Friederichs (1958)** defined ecology as '*The science of living beings as members of the whole of nature'*.

- **F. Fraster Darling (1963)** defined ecology as '*the science of organisms in relation to their total environment, and the inter-relationship of organisms inter-specifically and between themselves'*.
- **A.G. Tansley (1935)** introduced the term 'ecosystem' and led to the development of concepts of productivity and energy relations in ecology which is now referred to as **bioenergic** approach.

4. Principle Steps of Ecology

a) Reception of energy
b) Manufacture of organic food by producers
c) Consumption of organic matter by consumers
d) Decomposition to organic compounds
e) Transformation of these compounds into suitable compounds for the nutrition of the producers

5. Ecological Hierarchy

Ecology deals with the interactions of all the various levels of biological organization – organisms, populations, communities, ecosystems and biomes. The organization at several levels in an ascending order of complexity from a simple individual and culminate to a more complex biosphere is called ecological hierarchy. Each level is formed of the components of its lower level. To structure the study of ecology into a conceptually manageable framework, the biological world is organized into a nested hierarchy, ranging in scale from genes, to cells, to tissues, to organs, to organisms, to species, to populations, to communities, to ecosystems, to biomes, and up to the level of the biosphere (Fig. 2).

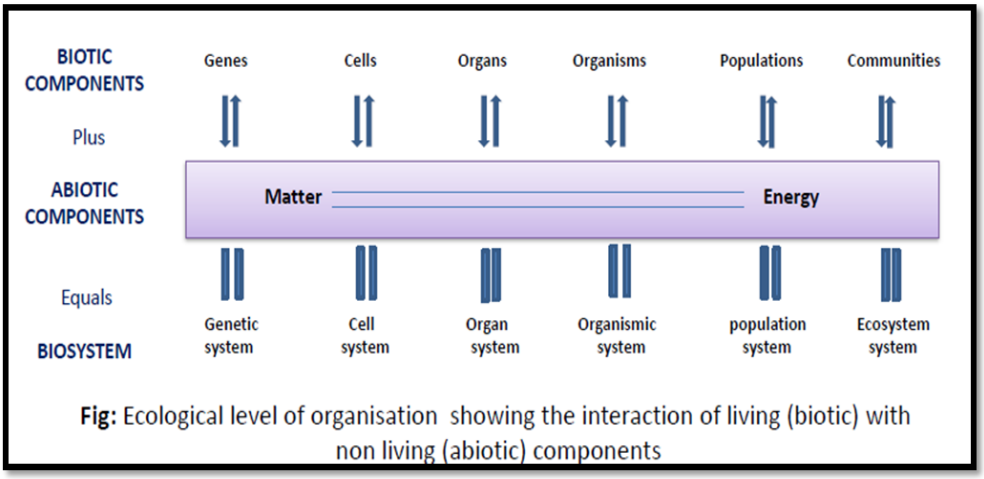

Fig.2: Ecological level of organization
(**Source:** Recreated from 'Fundamental of Ecology' Fifth Edition by E.P. Odum)

Understanding all the levels of ecological organizations in an ecological hierarchy is important to study a complete ecosystem. This structure forms a panarchy and exhibits non-linear behaviors. Behaviors corresponding to higher levels occur at slow rates. Conversely, lower organizational levels exhibit rapid rates. For example, individual tree leaves respond rapidly to momentary changes in physical factors, but the growth of the tree responds more slowly.

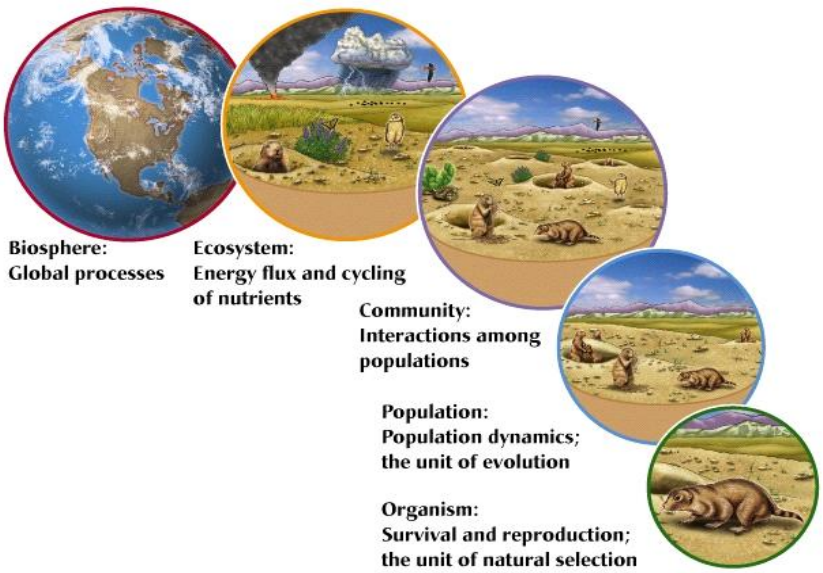

Fig.3: Levels of Ecological Organisation
Source: https://www.pinterest.com/pin/515451119825850583/

Fig. 3 shows the levels of organization. The different levels and important terms of ecological organization are given as follows:-

i) Individual organism is the basic unit of ecological hierarchy, being a distinct living, entity, continuously exchanging materials and information with its immediate environment and carrying out all life processes in its body, completely separate from other individuals. But constituents of an individual fail to survive alone.

ii) Population is a group of individuals of the same species living together in a common area at a particular given time. The study of populations is called **Demography.** It deals with the study of population size, density, population growth, population distribution pattern, survivorship curve and determination of population growth rate. Organisms from a population inhabiting in different geographical areas may form several other populations.

- Local population- It refers to the different populations of the same kind of an organism.
- Ecotype- It refers to the members of a local population which may be genetically adapted to their specific environment.
- Demes- It refers to sub-groups of a population in any given geographical area living in close interact with each other and mainly breeds among themselves.

(iii) Community or Biotic Community is a group of populations of different species, which live in a particular area. Populations do not exist in isolation. They interact with each other through mutualism, predation, competition etc. and form communities. These interactions regulate diversity and population growth.

(iv) Ecosystem is a fundamental unit of ecology consisting of biological community and its physical environment both interacting resulting in exchange of both materials and energy. It's being the most dynamic of all levels.

(v) Landscape is a unit of land distinguished by a natural boundary and having patches of different ecosystems.

(vi) Biome is a large regional unit delimited by a specific climatic zone, having a particular major vegetation zone and its associated fauna, e.g., tundra desert, temperate deciduous forest, tropical rain forest, ocean.

(vii) Biosphere is biologically inhabited part of earth along with its physical environment consisting of lower atmosphere, land and water bodies. It includes all ecosystems of this earth and their interrelationships.

In order to deeply understand the nature of these relationships and the systems to which they belong within the biosphere; global ecologists even today continue to look at the evolution and adaptation of organisms and how species and populations relate to one another as well as their environment.

6. Subdivision of Ecology

The scope of ecology has undergone sweeping change and the field of ecology has broadened substantially (Fig. 4). The study of ecology is centered on three main aspects:

i) Taxonomic Affinities
ii) Habitat and
iii) Levels of organisation.

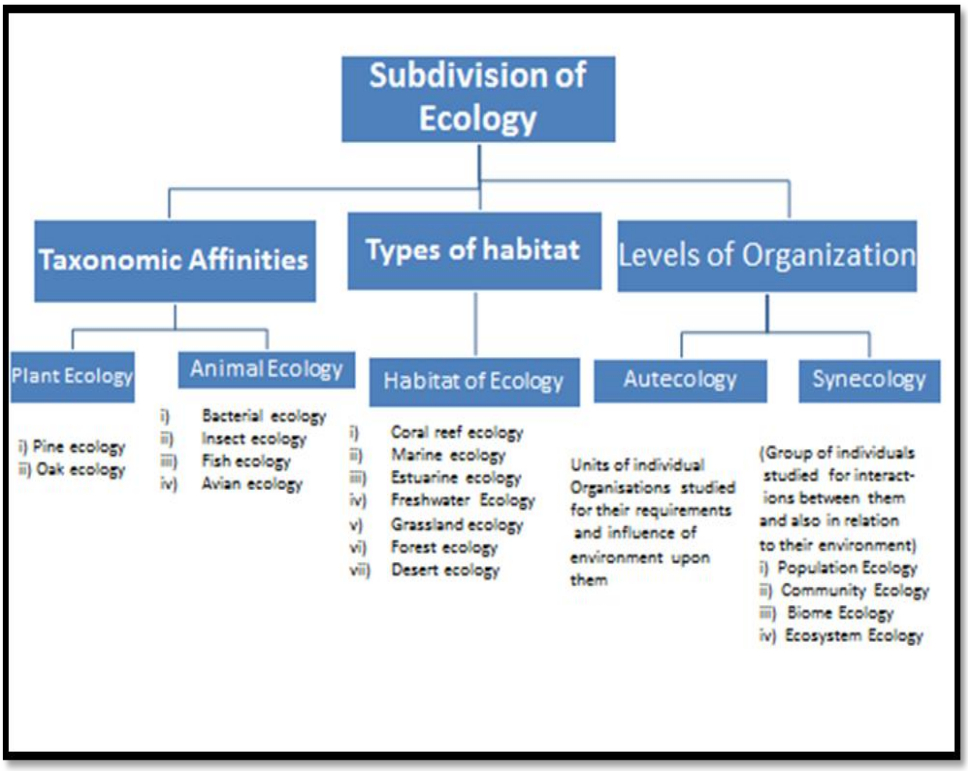

Fig. 4: Subdivisions of Ecology (**Source:** Author)

Emphasizing on individual organism or groups of organisms living in a particular ecosystem, ecology can mainly be divided into two types namely: autecology and synecology.

6.1. Autecology

It is the subdivision of ecology which deals with the ecological study of one species of organism throughout its life in relation to the ecological habitat factors like the life history, population dynamics, behavior, home range etc. thereby concentrating on the finer details of a particular organism. It sharply focuses on a particular organism with a purpose of seeing how it fits into general ecological picture. For example: Relationship of an oak tree to its environment.

6.2. Synecology

It deals with the ecological studies of communities or entire ecosystems, describing the overall energy and material flow through the system. Hence it is the study of groups of organisms in relation to its environment which are associated together as a unit. For example: tropical forests or deserts. Synecology is further subdivided into aquatic and terrestrial ecology;

In the words of Herreid II (1977) "*the two types of study, autecology and synecology, inter-relate, the synecologist painting with a broad brush the outline of the picture and autecologist stroking in the finer details*". Differences between the synecology and autecology are enumerated below in Table 2.

AUTECOLOGY	SYNECOLOGY
It is the study of an organism or a species or a population in relation to its environment	It is the study of group of organism or many species or communities in relation to their environment
It is occasionally referred to as population ecology	It is also referred to as community ecology
It is a comparatively simple experimental and inductive	It's a more complex, philosophical and deductive.
laboratory set up studies can be done using conventional mathematical tools to interpreted data	Since it's a more naturally formed system involving interactions lasting over hundreds of years hence cannot be accommodated in a lab set up.
The study is at the level of an individual, a population or an entire species	The study is at the highest level of biological organism; many population in an area (community) interacting with each other and the environment like ecosystem
Example: **Study of deer population in relation to its environment (involving factors like rainfall, hunting, lion population etc. in a grassland ecosystem).**	Example: Study of entire forest ecosystem (comprising all the species or communities)

Table 2: Differences between Synecology and Autecology

Source: http://www.majordifferences.com/2016/08/difference-between-autecology-and-synecology.html#.WJdKavl97IU

7. Ecosystem and Habitat

Habitat and *ecosystem* are two different components of ecology, but both those are found in one place. An *ecosystem* contains many *habitats, but it is the basic, dynamic and complex, natural, functional ecological unit of living organism and their environment.* An ecological

area inhabited by a particular species of living organism is known as the habitat. The term typically refers to the natural environmental zone in which the organism lives or the physical environment that surrounds a species population, where it can find food, shelter, protection and mates for reproduction. It is made up of physical factors such as soil, moisture, range of temperature, and intensity as well as biotic factors such as the availability of food and the presence or absence of predators. Hence habitat is a physical location where an organism or a community of organisms lives while **niche** on the other hand is that specific position of an organism resides in a community ecosystem (Fig: 5).

Fig. 5: Different types of habitats (**Source:** Author and Departmental Artist)

Every organism has a certain habitat need for the conditions in which it can thrive. Some species are tolerant of wide variations while others are very specific in their requirements. A habitat is not necessarily a geographical area, it can be the interior of a stem, a rotten log, a rock or a clump of moss, and for a parasitic organism it is the body of its host, part of the host's body such as the digestive tract, or a single cell within the host's body. Every *habitat* has distinct life forms living in it, forming complex communities of interdependent organisms. *Biomes* have many ecosystems, where several *habitats* meet. They include the geography and climate conditions of communities of plants, animals, and soil organisms.

Generally two key variables dictate the geographical distribution of Earth's different *habitat types*: precipitation and temperature. Habitat types include polar, temperate, subtropical and tropical. Habitats are also classified as terrestrial and aquatic habitats.

- Aquatic habitat includes fresh water, estuarine and marine habitat.
- Terrestrial habitat includes forest, grassland, cropland, desert habitat etc. and is concerned with their microclimate, soil chemistry, nutrient, hydrological cycle and productivity.

The different types of terrestrial habitats are given in the Table 3:

Name of Biome	Region	Flora and Fauna
1. Tundra	Northern most adjoining the ice bound poles	Devoid of trees except stunted shrubs in the southern part, ground flora includes lichen, mosses and sedge. The typical animals are reindeer, arctic fox, polar bear, snowy owl, lemming, arctic hare, patarmigan. Reptiles and amphibians are almost absent.
2. Taiga	Northern Europe, Asia and Northern America but in areas of more moderate temperature tha tundra. Also known as boreal forest.	The dominant vegetation is coniferous evergreens mostly spruce, with some pine and firs. The fauna consist of small seed eating birds, hawks, fur bearing carnivores, little mink, elks, puma, Siberian tiger, wolverine, wolves etc.
3. Temperate deciduous forest	Extends over Central and Southern Europe, eastern, northern America, Western China, Japan, New Zealand etc. Temperature on an average is moderate and rainfall is abundant. These are generally the most productive agricultural areas of the earth.	The flora includes trees like beech, oak, maple and cherry. Most animal are the familiar vertebrates and invertebrates.
4. Tropical Rain Forest	Tropical areas of high rainfall in the equatorial regions, which abound with life. Temperature is high	Tropical rainforest covers only about 7% of the earth's surface and houses. 40% of the world's plant and animal species. Mulitiplestorey of broad-leafed evergreen tree species are in abundance. Most animals and epiphytic plants are concentrated in the canopy or tree top zones.
5. Savannah	Tropical region: Savannah is most extensive in Africa	Grasses with scattered trees and fire resisting thorny shrubs. The fauna include a great diversity of grazers and browsers such as

		antelopes, buffaloes, zebras, elephants and rhinoceros; the carnivores include lion, cheetah, hyena; and mongoose and many rodents.
6. Grasslands	Northern America Midwest and Ukraine: dominated by grasses. Temperate conditions with rather low rainfall.	Grass dominates the vegetation. The fauna include large herbivores like bison, antelope, cattle, rodent, prairie, dog, wolves and a rich and diverse array of ground nesting bird.
7. Dessert	Continental interiors with very low and sporadic rainfall with low humidity. The days are very hot but nights are cold.	The flora is drought resistance vegetation such as cacti, euphorbias, sagebrush. Many species of reptiles mammals and birds occur.

Aquatic habitat can broadly be divided into the following:

Biomes	Characteristics
Fresh Water Ecosystem	Fresh water ecosystem are characteristics as lotic (having flowing water) or lentic (still or stagnant water). Lotic water systems include freshwater streams, springs, rivulets, creeks, brooks and rivers. Lentic water bodies include pools, ponds, some swamps, bogs and lakes. They vary considerably in physical, chemical and biological characteristics.
Estuaries	Coastal bays, river mouths and tidal marshes from the estuaries. In estuaries, fresh water from rivers meets ocean water, and the two are mixed by action of tides. Estuaries are highly productive as compared to adjacent river or sea
Marine Ecosystem	Nearly three-quarter of earth's surface is covered by ocean with an average depth of 3,750 meters and with salinity 35 ppt., (parts per thousand), about 90% of which is sodium chloride.

Table 3: Different types of terrestrial

Fresh water habitats include marshes, streams, rivers, lakes, ponds and estuaries. Marine habitats include salt marshes, the coast, the intertidal zone, reefs, bays, the open sea, the sea bed, deep water and submarine vents.

Habitats change over time. This may be due to sudden changes such as the eruption of a volcano, an earthquake, a tsunami, a wild fire etc; or the change may be more gradual over millennia with alterations in the climate, like ice sheets and glaciers advance and retreat, also different weather patterns may bring changes of precipitation and solar radiation. Human activities like deforestation, the ploughing of ancient grasslands, the diversion and damming of rivers, the draining of marshland and the dredging of the seabed can also result in habitat

make over. Man-made changes, hunting or increased predation also leads to habitat changes through competition for resources or through the introduction of pests and diseases to which the native species might have no immunity.

So, an *ecosystem* is a complex set of relationships among the living resources, habitats, and residents of an area. It includes all of the living things in a given area, interacting with each other, and also with their non-living immediate environments.

8. Summary

- Ecology is an interdisciplinary field of science, originating from biology and is interrelated with varied fields even apart from science. It is an ever - evolving discipline with futuristic implications.
- Ecologists need knowledge of many subjects to fully understand any ecosystem in depth.
- Ecology involves the scientific study of the distributions, abundance and relations of organisms and their interactions with the physical environment. Since, the survival of any organism (from the largest animals to bacteria invisible to the human eye), depends on its interaction with the environment; therefore, the systematic study of ecology is of prime importance to the protection and survival of life on planet earth as well as in exploring the possibilities of life in outer space (currently at Mars).
- An ecosystem is the most important complete unit amongst all the levels of organisational hierarchy, with organism (individual of a species) being its simplest level and biosphere being the most complex level of all.
- Habitat is termed as the physical location of a community of a particular ecosystem. Similar organisms form a population and different populations (of dissimilar species) in varied habitats together form a community. Many communities co-exist in an ecosystem where energy flux and cycling of nutrients takes place.
- *Biomes* are distinct biological communities that have formed in response to a shared physical climate. A *biome* is NOT an ecosystem, although in a way it can look like a massive ecosystem. They are a way to divide Earth's surface.

- Ecosystem simply means ‘ecological systems’ and ecology in simple terms is the study of ecosystems, which can be huge in size or relatively small. Our planet Earth is the biggest ecosystem of the entire universe. It is a bit unfortunate but ecosystems have been destroyed and vanished by man-made activities like deforestation, urbanization and natural activities like floods, storms, fires or volcanic eruptions.
- The study done by ecologists can help us to better understand the world around us and can influence our lives in a positive way by improving the environment of our surroundings, managing our natural resources judiciously and protecting the public health of the masses in general.