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## CHAPTER 1 - ECOLOGY

Ecology is made of two Latin words - 'Oikos' meaning home or place to live in and 'logos' meaning study.

Literally it is the study of the home of nature.

Ecology is defined "as a scientific study of the relationship of the living organisms with each other and with their environment."

It deals with the ways in which organisms are moulded by their environment, how they make use of environmental resources including energy flow and mineral cycling.

### Environment and its component

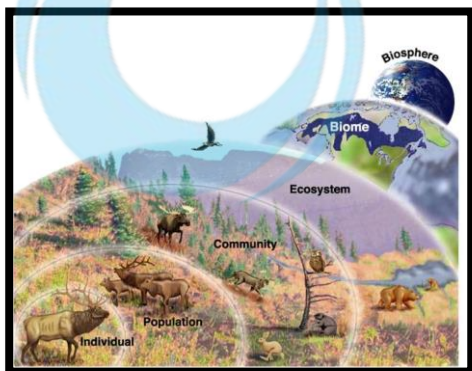
Everything that surrounds or affects an organism during its life time is collectively known as its environment.

The environment is defined as 'the sum total of living, non-living components; influences and events, surrounding an organism.'

Components of Environment	
Abiotic	Biotic
Energy	Green plants
Radiation	Non-green plants
Temperature & heat flow	Decomposers
Water	Parasites
Atmospheric gases and wind	Symbionts
Fire	Animals
Gravity	Man
Topography	
Soil	
Geologic substratum	

### Levels of organisations in ecology

The main levels of organisation of ecology are six and are as follows:



Credits: <https://socratic.org/questions/what-levels-of-organization-include-abiotic-factors>

### Individual

- Organism is an individual living being that has the ability to act or function independently.
- It may be plant, animal, bacterium, fungi, etc.
- It is a body made up of organs, organelles, or other parts that work together to carry out on the various processes of life.

### Population

- Population is a group of organisms usually of the same species, occupying a defined area during a specific time.
- Population growth rate is the percentage variation between the number of individuals in a population at two different times. Therefore, the population growth rate can be positive or negative.
- The main factors that make population increase are birth and immigration.
- The main factors that make population decrease are death and emigration.
- Population density is the relation between the number of individuals of a population and the area they occupy.

### Community

- In order to survive, individuals of any one species depend on individuals of different species with which they actively interact in several ways.

For eg: Animals require plants for food and trees for shelter. Plants require animals for pollination, seed dispersal, and soil microorganism to facilitate nutrient supply.

A community is a group or association of populations of two or more different species occupying the same geographical area at the same time.

Communities in most instances are named after the dominant plant form (species).

Example: A grassland community is dominated by grasses, though it may contain herbs, shrubs, and trees, along with associated animals of different species.

A community is not fixed or rigid; communities may be large or small.

## Types of Community

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

### Major Community

- These are large-sized, well organized and relatively independent.
- They depend only on the sun's energy from outside and are independent of the inputs and outputs from adjacent communities.
- E.g: tropical ever green forest in the North-East

### Minor Communities

- These are dependent on neighbouring communities and are often called societies.
- They are secondary aggregations within a major community and are not therefore completely independent units as far as energy and nutrient dynamics are concerned.
- e.g: A mat of lichen on a cow dung pad.

### Structure of a community

In a community the number of species and size of their population vary greatly.

The environmental factors determine the characteristic of the community as well as the pattern of organisation of the members in the community.

The characteristic pattern of the community is termed as structure which is reflected in the roles played by various population, their range, the type of area they inhabit, the diversity of species in the community and the spectrum of interactions between them.

### Ecosystem

- An ecosystem is defined as a structural and functional unit of biosphere consisting of community of living beings and the physical environment, both interacting and exchanging materials between them.
- It includes plants, trees, animals, fish, birds, micro-organisms, water, soil, and people.
- Ecosystems vary greatly in size and elements but each is a functioning unit of nature.
- Everything that lives in an ecosystem is dependent on the other species and

elements that are also part of that ecological community. If one part of an ecosystem is damaged or disappears, it has an impact on everything else.

- When an ecosystem is healthy, it means that all the elements live in balance and are capable of reproducing themselves.
- Ecosystem can be as small as a single tree or as large as entire forest.

### Components of Ecosystem

The components of ecosystem and environment are same.

#### Abiotic Components

- Abiotic components are the inorganic and non-living parts of the world.
- The abiotic part consists of soil, water, air, and light energy etc. It also involves chemicals like oxygen, nitrogen etc. and physical processes including volcanoes, earthquakes, floods, forest fires, climates, and weather conditions.
- Abiotic factors are the most important determinants of where and how well an organism exists in its environment.

#### Energy

- Energy from the sun is essential for maintenance of life.
- In the case of plants, the sun directly supplies the necessary energy.
- Since animals cannot use solar energy directly, they obtain it indirectly by eating plants or animals or both.
- Energy determines the distribution of organisms in the environment.

#### Rainfall

- Water is essential for all living beings.
- Majority of biochemical reactions take place in an aqueous medium.
- Water helps to regulate body temperature.
- Further, water bodies form the habitat for many aquatic plants and animals.

#### Temperature

- Temperature is a critical factor of the environment which greatly influences survival of organisms.
- Organisms can tolerate only a certain range of temperature and humidity.



## Atmosphere

The earth's atmosphere is responsible for creating conditions suitable for the existence of a healthy biosphere on this planet.

## Materials

- Organic compounds such as proteins, carbohydrates, lipids, humic substances are formed from inorganic compound on decomposition.
- Inorganic compounds such as carbon dioxide, water, sulphur, nitrates, phosphates, and ions of various metals are essential for organisms to survive.

## Latitude and altitude

- Latitude has a strong influence on an area's temperature, resulting in change of climates such as polar, tropical, and temperate.
- These climates determine different natural biomes.
- From sea level to highest peaks, wild life is influenced by altitude.
- As the altitude increases, the air becomes colder and drier, affecting wild life accordingly.

## Biotic Components

Biotic components include living organisms comprising plants, animals and microbes and are classified according to their functional attributes into producers and consumers.

### Primary producers - Autotrophs (self-nourishing)

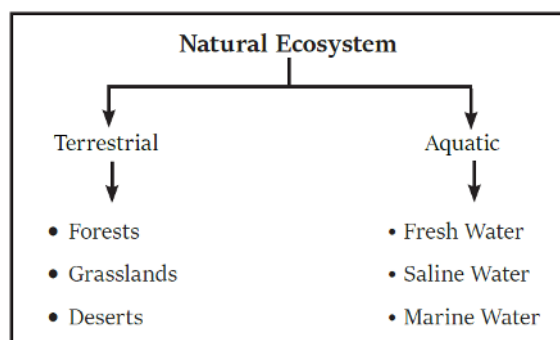
- Primary producers are basically green plants (and certain bacteria and algae).
- They synthesise carbohydrate from simple inorganic raw materials like carbon dioxide and water in the presence of sunlight by the process of photosynthesis for themselves, and supply indirectly to other non-producers.
- In terrestrial ecosystem, producers are basically herbaceous and woody plants, while in aquatic ecosystem producers are various species of microscopic algae.

### Consumers - Heterotrophs or phagotrophs (other nourishing)

- Consumers are incapable of producing their own food (photosynthesis).
- They depend on organic food derived from plants, animals or both.
- Consumers can be divided into two broad groups namely micro and macro consumers.

Macro consumers	Micro consumers - Saprotrophs (decomposers or osmotrophs)
<ul style="list-style-type: none"> <li>• They feed on plants or animals or both and are categorised on the basis of their food sources.</li> </ul>	<ul style="list-style-type: none"> <li>• They are bacteria and fungi which obtain energy and nutrients by decomposing dead organic substances (detritus) of plant and animal origin.</li> </ul>
<ul style="list-style-type: none"> <li>• Herbivores are primary consumers which feed mainly on plants e.g. cow, rabbit.</li> </ul>	<ul style="list-style-type: none"> <li>• The products of decomposition such as inorganic nutrients which are released in the ecosystem are reused by producers and thus recycled.</li> </ul>
<ul style="list-style-type: none"> <li>• Secondary consumers feed on primary consumers e.g. wolves.</li> <li>• Carnivores which feed on secondary consumers are called tertiary consumers e.g. lions which can eat wolves.</li> <li>• Omnivores are organisms which consume both plants and animals e.g. man, monkey.</li> </ul>	<ul style="list-style-type: none"> <li>• Earthworm and certain soil organisms (such as nematodes, and arthropods) are detritus feeders and help in the decomposition of organic matter and are called detritivores.</li> </ul>

## Classification of Eco-system



Ecosystems are capable of maintaining their state of equilibrium. They can regulate their own species structure and functional processes. This capacity of ecosystem of self-regulation is known as homeostasis.

### Ecosystem Services

As per Millennium Ecosystem Assessment (MEA), 2005 ecosystem services are grouped into four categories

#### Provisioning services

- food, crops, and spices
- water
- building materials
- pharmaceuticals, biochemicals, and industrial products
- energy (hydropower, biomass fuels)

#### Regulating services

- carbon sequestration and climate regulation
- waste decomposition and detoxification
- purification of water and air
- crop pollination
- pest and disease control

#### Supporting services

- nutrient dispersal and cycling
- seed dispersal

#### Cultural services

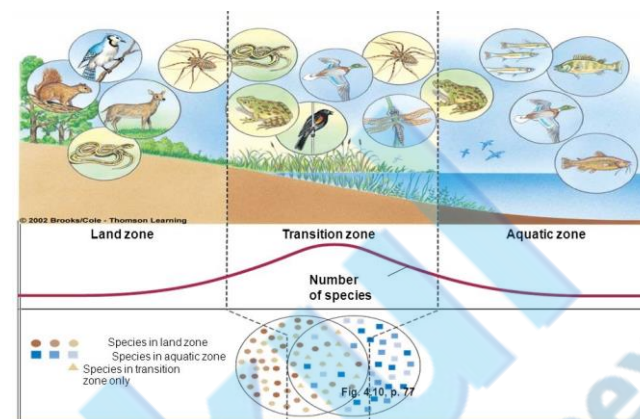
- cultural, intellectual and spiritual inspiration
- recreational experiences (including ecotourism)

### Ecotone

Ecotone is a zone of junction between two or more diverse ecosystems. For e.g. the mangrove

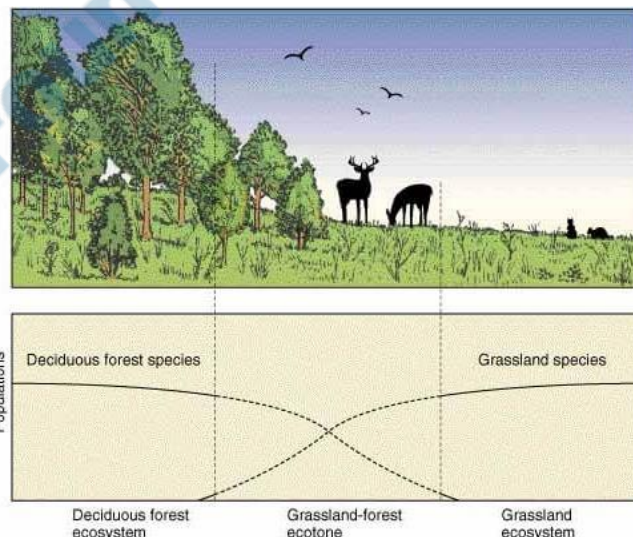
forests represent an ecotone between marine and terrestrial ecosystem.

Other examples are – grassland, estuary, marshlands and mangrove forests.



### Characteristics of Ecotone

- It may be very narrow or quite wide.
- It has the conditions intermediate to the adjacent ecosystems. Hence it is a zone of tension.
- It is linear as it shows progressive increase in species composition of one in coming community and a simultaneous decrease in species of the other outgoing adjoining community.



- A well-developed ecotones contain some organisms which are entirely different from that of the adjoining communities.
- Sometimes the number of species and the population density of some of the species is much greater in this zone than either community. This is called edge effect.
- The organisms which occur primarily or most abundantly in this zone are known as edge species.

## Niche

A niche is the unique functional role or place of a species in an ecosystem.

It is a description of all the biological, physical and chemical factors that a species needs to survive, stay healthy and reproduce.

A niche is unique for a species, which means no two species have exact identical niches.

Niche plays an important role in conservation of organisms.

If we have to conserve species in its native habitat we should have knowledge about the niche requirements of the species and should ensure that all requirements of its niche are fulfilled.

## Types of Niche

- Habitat niche** – where it lives
- Food niche** – what it eats or decomposes & what species it competes with
- Reproductive niche** – how and when it reproduces.
- Physical & chemical niche** – temperature, land shape, land slope, humidity & other requirements.

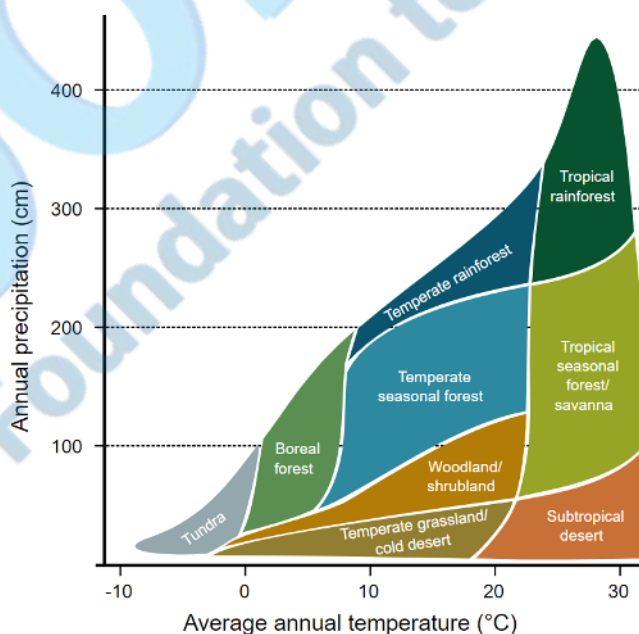
## Difference between niche and habitat

- The habitat of a species is like its 'address' (i.e. where it lives) whereas niche can be thought of as its "profession" (i.e. activities and responses specific to the species).
- A niche is unique for a species while many species share the habitat.

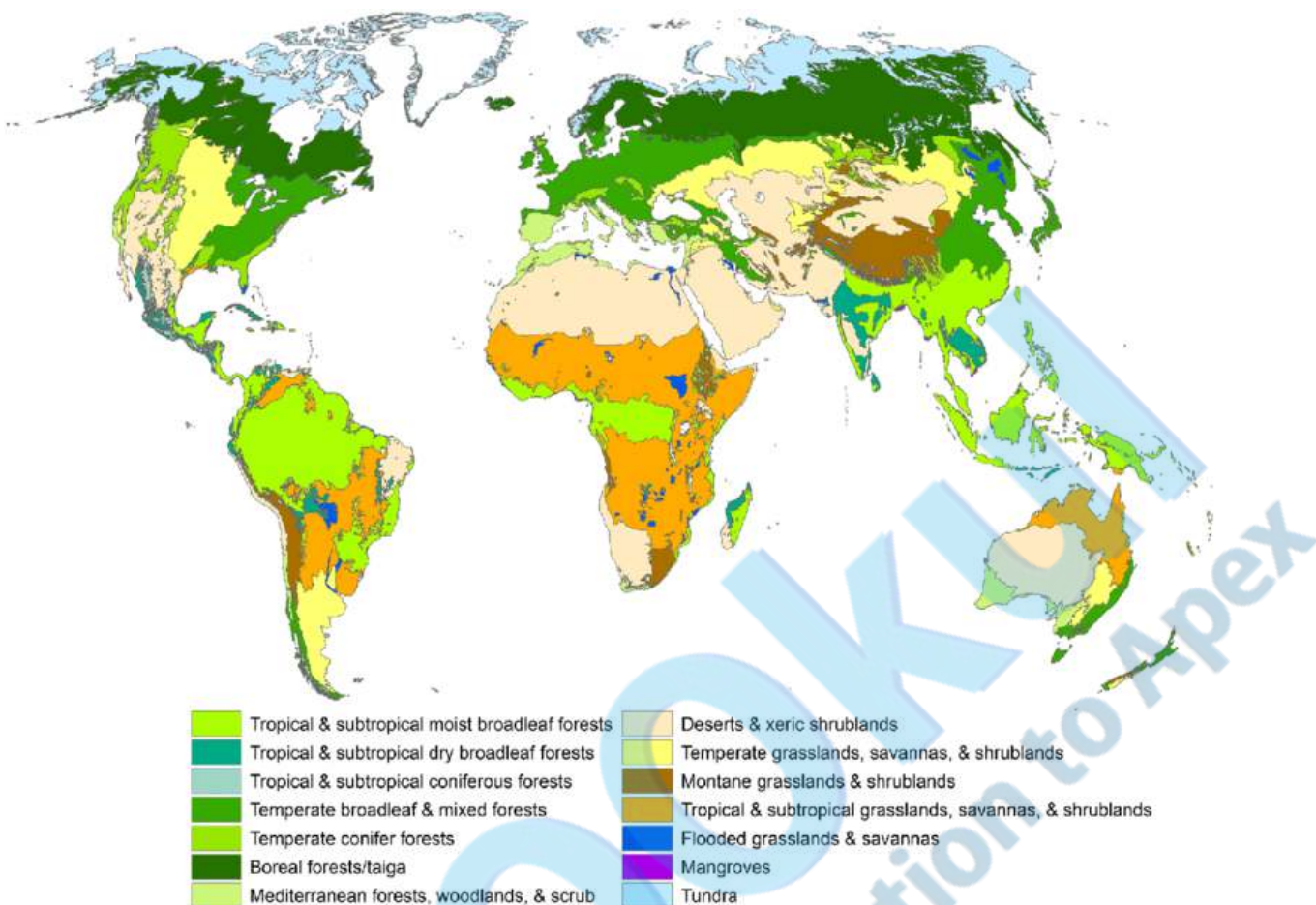
- No two species in a habitat can have the same niche. This is because of the competition with one another until one is displaced.
- For example, a large number of different species of insects may be pests of the same plant, but they can co-exist as they feed on different parts of the same plant.

## Biome

- The terrestrial part of the biosphere is divisible into enormous regions called biomes, which are characterized, by climate, vegetation, animal life and general soil type.
- No two biomes are alike.
- The climate determines the boundaries of a biome and abundance of plants and animals found in each one of them.
- The most important climatic factors are temperature and precipitation.



S.No.	Name of Biome	Region	Flora and Fauna
1	Tundra	Northern and Southern most region of world adjoining the ice bound poles	Devoid of trees except stunted shrubs in the southern part of tundra biome, ground flora includes lichen, mosses and sedges. The typical animals are reindeer, arctic fox, polar bear, snowy owl, lemming, arctic hare, ptarmigan. Reptiles and amphibians are almost absent.
2	Taiga	Northern Europe, Asia and North America. Moderate temperature than tundra. Also known as boreal forest.	The dominating vegetation is coniferous evergreen mostly spruce, with some pine and firs. The fauna consists of 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 North America, Western China, Japan, New Zealand etc. Moderate average temperature and abundant rainfall.	The flora includes trees like beech, oak, maple and cherry. Most animals are the familiar vertebrates and invertebrates. These are generally the most productive agricultural areas of the earth
4	Tropical rain forest	Tropical areas in the equatorial regions, which is abound with life. Temperature and rainfall high.	Tropical rainforest covers about 7% of the earth's surface & 40% of the world's plant and animal species. Multiple storey 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	Grassland	North America, Ukraine, etc. Temperate conditions with low rainfall.	Grasses dominate the vegetation. The fauna include large herbivores like bison, antelope, cattle, rodents, prairie dog, wolves, and a rich and diverse array of ground nesting bird.
7	Desert	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 such as cactus, euphorbias, sagebrush. Fauna: Reptiles, Small Mammals and birds.



### Aquatic Zones

Aquatic systems are not called biomes, however they are divided into distinct life zones, with regions of relatively distinct plant and animal life.

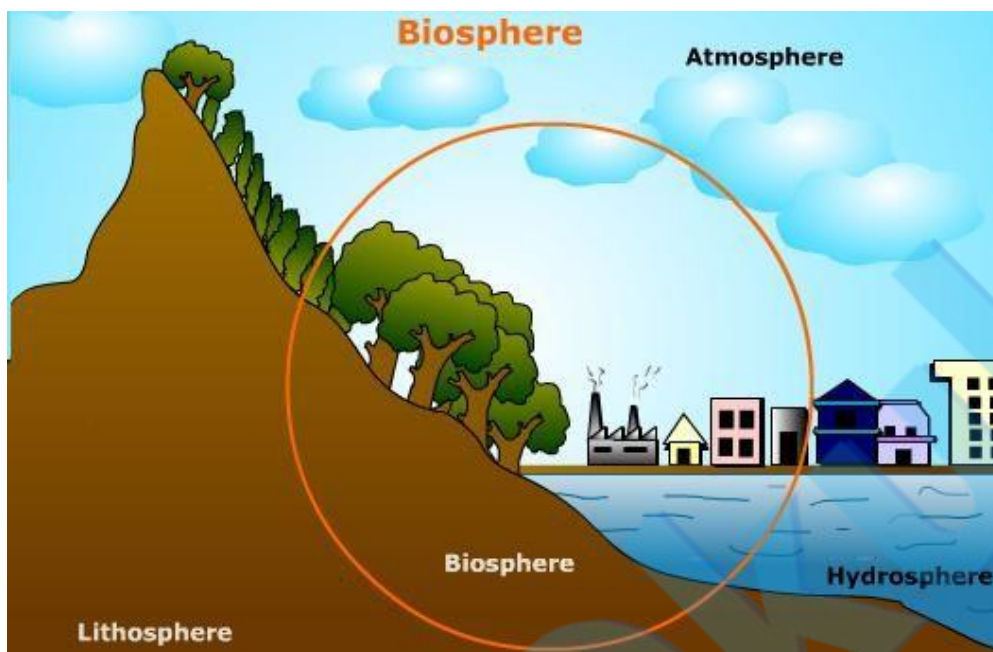
The major differences between the various aquatic zones are due to salinity, levels of dissolved nutrients, water temperature, depth of sunlight penetration.

S.No	Aquatic ecosystem	Characteristics
1.	Fresh Water Ecosystem	Fresh water ecosystem are classified as lotic (moving water) or lentic (still or stagnant water). Lotic water system includes 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.
2.	Marine Ecosystem	Nearly three - quarter of earth's surface is covered by ocean with an average depth of 3,750 m and with salinity 35 ppt, (parts per thousand), about 90 per cent of which is sodium chloride.
3.	Estuaries	Coastal bays, river mouths and tidal marshes form the estuaries. In estuaries, fresh water from rivers meet ocean water and the two are mixed by action of tides. Estuaries are highly productive as compared to the adjacent river or sea.
4.	Coral reef	
5.	Mangrove	

### Biosphere

- Biosphere is a part of the earth where life can exist.

- Biosphere represents a highly integrated and interacting zone comprising of atmosphere (air), hydrosphere (water) and lithosphere (land).



- It is a narrow layer around the surface of the earth. If we visualise the earth to be the size of an apple the biosphere would be as thick as its skin.
- Life in the biosphere is abundant between 200 metres (660 feet) below the surface of the ocean and about 6,000 metres (20,000 feet) above sea level.

Biosphere is absent at extremes of the North and South poles, the highest mountains and the deepest oceans, since existing hostile conditions there do not support life.

Occasionally spores of fungi and bacteria do occur at great height beyond 8,000 metres, but

they are not metabolically active, and hence represent only dormant life.

- The energy required for the life within the biosphere comes from the sun.
- The nutrients necessary for living organisms come from air, water and soil. The same chemicals are recycled over and over again for life to continue.
- Living organisms are not uniformly distributed throughout the biosphere. Only a few organisms live in the polar regions, while the tropical rain forests have an exceedingly rich diversity of plants and animals (50% of Global Biodiversity).

## CHAPTER 2 – FUNCTIONS OF AN ECOSYSTEM

The function of an ecosystem is a broad, vast and complete dynamic system. It can be studied under the following three heads.

- Energy flow
- Nutrient cycling (biogeochemical cycles)
- Ecological succession or ecosystem development

### Energy flow

Energy is the basic force responsible for all metabolic activities.

The flow of energy from producer to top consumers is called energy flow which is unidirectional.

The study of Trophic level interaction in an ecosystem gives an idea about the energy flow through the ecosystem.

### Trophic level interaction

Trophic level interaction deals with how the members of an ecosystem are connected based on nutritional needs.

Trophic levels (Trophe = nourishment)		
I	Autotrophs	Green plants (producers)
II	Heterotrophs	Herbivore (primary consumers)
III	Heterotrophs	Carnivores (secondary consumers)
IV	Heterotrophs	Carnivore (tertiary consumers)
V	Heterotrophs	Top carnivores (Quarternary consumers)

- Energy flows through the trophic levels: from producers to subsequent trophic levels.
- This energy always flows from lower (producer) to higher (herbivore, carnivore etc.) trophic level. It never flows in the reverse direction that is from carnivores to herbivores to producers.
- There is a loss of some energy in the form of unusable heat at each trophic level so that energy level decreases from the first trophic level upwards.
- As a result, there are usually four or five trophic levels and seldom more than six as beyond that very little energy is left to

support any organism. Trophic levels are numbered according to the steps an organism is away from the source of food or energy, that is the producer.

The trophic level interaction involves three concepts namely,

- Food Chain
- Food Web
- Ecological Pyramids

### Food chain

- Organisms in the ecosystem are related to each other through feeding mechanism or trophic levels, i.e., one organism becomes food for the other.
- A sequence of organisms that feed on one another, form a food chain.
- A food chain starts with producers and ends with top carnivores.
- The sequence of eaten and being eaten, produces transfer of food energy and it is known as food chain.
- The plant converts solar energy into chemical energy by photosynthesis.
- Small herbivores consume the plant matter and convert them into animal matter.
- These herbivores are eaten by large carnivores.

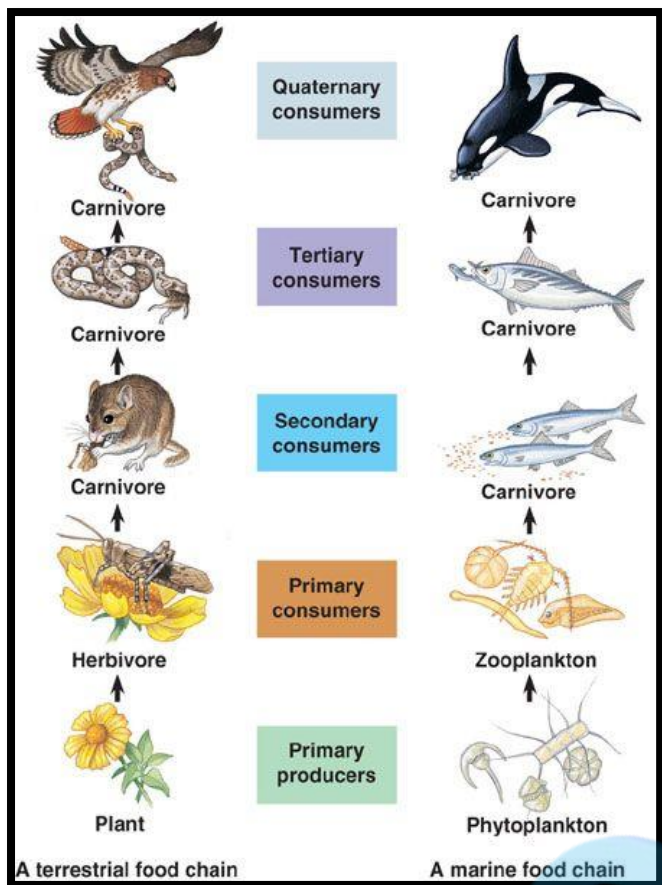
### Types of Food Chains

In nature, two main types of food chains have been distinguished.

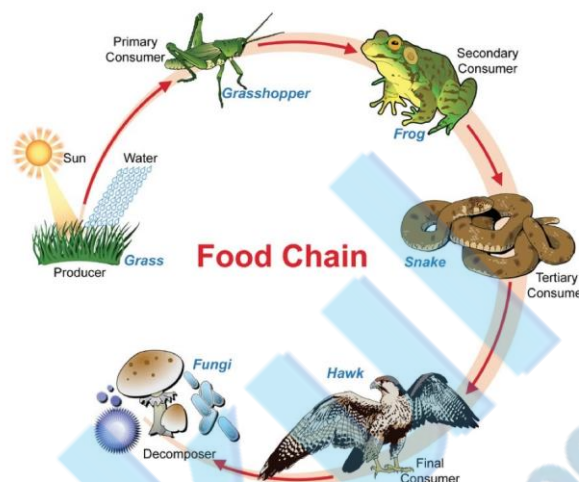
#### Grazing food chain

The consumers which start the food chain, utilising the plant or plant part as their food, constitute the grazing food chain.

This food chain begins from green plants at the base and the primary consumer is herbivore.



waste materials and dead organic matter from the grazing food chain.

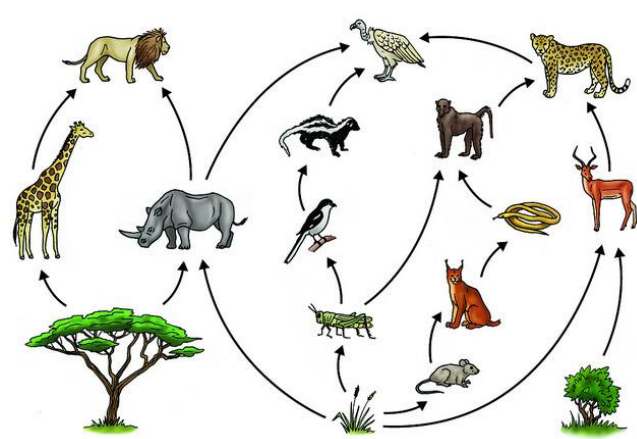


### Food web

A food chain represents only one part of the food or energy flow through an ecosystem and implies a simple, isolated relationship, which seldom occurs in the ecosystems.

An ecosystem may consist of several interrelated food chains. More typically, the same food resource is part of more than one chain, especially when that resource is at the lower trophic levels.

“A food web illustrates, all possible transfers of energy and nutrients among the organisms in an ecosystem, whereas a food chain traces only one pathway of the food”.

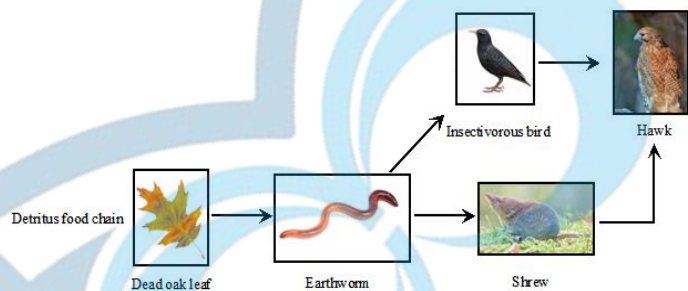


If any of the intermediate food chain is removed, the succeeding links of the chain will be affected largely.

The food web provides more than one alternative for food to most of the organisms in

### Detritus food chain

It starts from dead organic matter of decaying animals and plant bodies consumed by the micro-organisms and then to detritus feeding organism called detrivores or decomposer and to other predators.



The distinction between these two food chains is the source of energy for the first level consumers.

In the grazing food chain the primary source of energy is living plant biomass while in the detritus food chain the source of energy is dead organic matter or detritus.

The two food chains are linked. The initial energy source for detritus food chain is the



an ecosystem and therefore increases their chance of survival.

For example, grasses may serve food for rabbit or grasshopper or goat or cow. Similarly a herbivore may be food source for many carnivorous species.

## Ecological pyramids

The steps of trophic levels expressed in a diagrammatic way are referred as ecological pyramids.

The food producer forms the base of the pyramid and the top carnivore forms the tip. Other consumer trophic levels are in between.

The pyramid consists of a number of horizontal bars depicting specific trophic levels which are arranged sequentially from primary producer level through herbivore, carnivore onwards.

The length of each bar represents the total number of individuals at each trophic level in an ecosystem.

The number, biomass and energy of organisms gradually decrease with each step from the producer level to the consumer level and the diagrammatic representation assumes a pyramid shape.

The ecological pyramids are of three categories.

- Pyramid of numbers,
- Pyramid of biomass, and
- Pyramid of energy or productivity

### Pyramid of Numbers

This deals with the relationship between the numbers of primary producers and consumers of different levels.

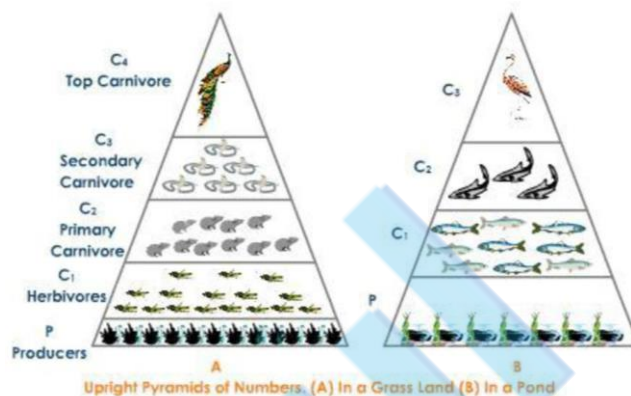
It is a graphic representation of the total number of individuals of different species, belonging to each trophic level in an ecosystem.

Depending upon the size and biomass, the pyramid of numbers may not always be upright, and may even be completely inverted.

### Pyramid of numbers - upright

In this pyramid, the number of individuals is decreased from lower level to higher trophic level.

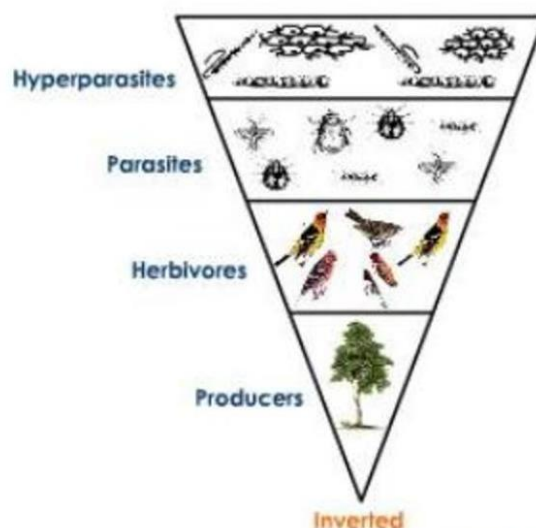
This type of pyramid can be seen in grassland ecosystem.



- The grasses occupy the lowest trophic level (base) because of their abundance.
- The next higher trophic level is primary consumer - herbivore (example - grasshopper). The individual number of grasshoppers is less than that of grass.
- The next energy level is primary carnivore (example - rat). The number of rats is less than grasshopper, because, they feed on grasshopper.
- The next higher trophic level is secondary carnivore (example - snakes). They feed on rats.
- The next higher trophic level is the top carnivore. (Ex. Hawk).
- With each higher trophic level, the number of individual decreases.

### Pyramid of numbers - inverted

In this pyramid, the number of individuals is increased from lower level to higher trophic level.



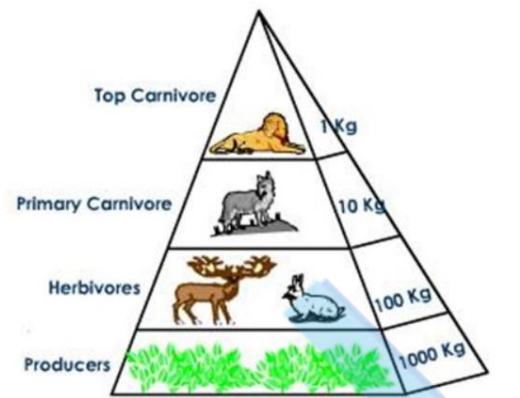
- A count in a forest would have a small number of large producers, for e.g. few number of big trees.
- This is because the tree (primary producer) being few in number and would represent the base of the pyramid and the dependent herbivores (Example - Birds) in the next higher trophic level and it is followed by parasites in the next trophic level. Hyper parasites being at higher trophic level represents higher in number.
- And the resulting pyramid is in inverted shape. A pyramid of numbers does not take into account the fact that the size of organisms being counted in each trophic level can vary.
- It is very difficult to count all the organisms, in a pyramid of numbers and so the pyramid of number does not completely define the trophic structure for an ecosystem.

### Pyramid of Biomass

- In order to overcome the shortcomings of pyramid of numbers, the pyramid of biomass is used.
- In this approach individuals in each trophic level are weighed instead of being counted.

- This gives us a pyramid of biomass, i.e., the total dry weight of all organisms at each trophic level at a particular time.
- Pyramid of biomass is usually determined by collecting all organisms occupying each trophic level separately and measuring their dry weight.
- This overcomes the size difference problem because all kinds of organisms at a trophic level are weighed. Biomass is measured in  $g/m^2$ .

### Upward pyramid

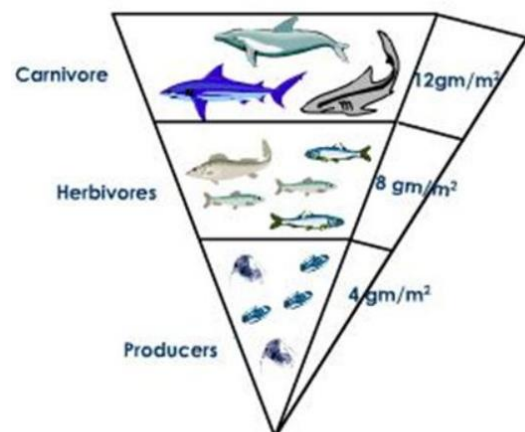


Upright Pyramid of biomass in a Terrestrial Ecosystem

- For most ecosystems on land, the pyramid of biomass has a large base of primary producers with a smaller trophic level perched on top.
- The biomass of producers (autotrophs) is at the maximum.
- The biomass of next trophic level i.e., primary consumers is less than the producers.
- The biomass of next higher trophic level i.e., secondary consumers is less than the primary consumers.
- The top, high trophic level has very less amount of biomass.

### Inverted pyramid

In contrast, in many aquatic ecosystems, the pyramid of biomass may assume an inverted form.



Inverted Pyramid in an Aquatic Ecosystem

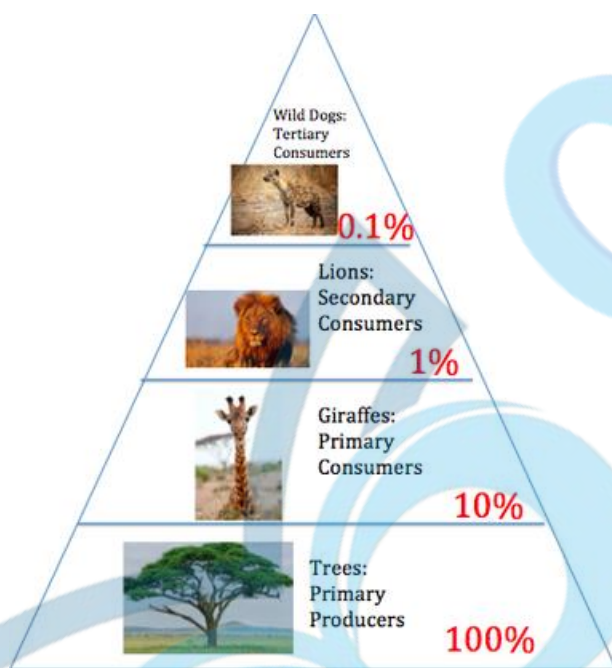
- This is because the producers are tiny phytoplanktons that grow and reproduce rapidly.

- Here, the pyramid of biomass has a small base, with the consumer biomass at any instant actually exceeding the producer biomass and the pyramid assumes inverted shape.

### Pyramid of Energy

To compare the functional roles of the trophic levels in an ecosystem, an energy pyramid is most suitable.

An energy pyramid, reflects the laws of thermodynamics, with conversion of solar energy to chemical energy and heat energy at each trophic level and with loss of energy being depicted at each transfer to another trophic level. Hence the pyramid is always upward, with a large energy base at the bottom.



Suppose an ecosystem receives 1000 calories of light energy in a given day.

Most of the energy is not absorbed; some is reflected back to space; of the energy absorbed only a small portion is utilised by green plants, out of which the plant uses up some for respiration and of the 1000 calories, therefore only 100 calories are stored as energy rich materials.

Now suppose an animal, say a giraffe, eats the plant containing 100 cal of food energy. The

giraffe uses some of it for its own metabolism and stores only 10 cal as food energy.

A lion that eats the deer gets an even smaller amount of energy.

Thus, usable energy decreases from sunlight to producer to herbivore to carnivore.

Therefore, the energy pyramid will always be upright.

*Energy pyramid concept helps to explain the phenomenon of biological magnification-the tendency for toxic substances to increase in concentration progressively at higher levels of the food chain.*

### Pollutants and trophic level

Pollutants especially nondegradable ones move through the various trophic levels in an ecosystem.

Nondegradable pollutants mean materials, which cannot be metabolized by the living organisms.

Example: chlorinated hydrocarbons.

We are concerned about these phenomena because, together they enable even small concentrations of chemicals in the environment to find their way into organisms in high enough dosages to cause problems.

Movement of these pollutants involves two main processes:

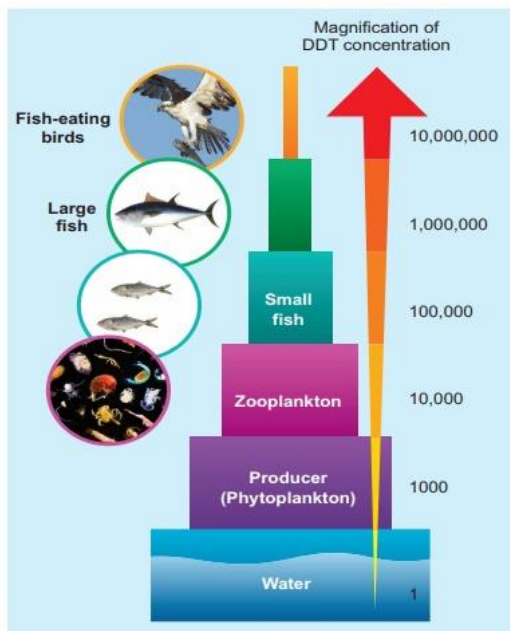
- Bioaccumulation
- Biomagnification

#### Bioaccumulation

- It refers to how pollutants enter a food chain.
- In bioaccumulation there is an increase in concentration of a pollutant from the environment to the first organism in a food chain.

#### Biomagnification

- Biomagnification refers to the tendency of pollutants to concentrate as they move from one trophic level to the next.
- Thus, in biomagnification there is an increase in concentration of a pollutant from one link in a food chain to another.



In order for biomagnification to occur, the pollutant must be: long-lived, mobile, soluble in fats, biologically active.

- If a pollutant is short-lived, it will be broken down before it can become dangerous.
- If it is not mobile, it will stay in one place and is unlikely to be taken up by organisms.
- If the pollutant is soluble in water, it will be excreted by the organism. Pollutants that dissolve in fats, however, may be retained for a long time.
- It is traditional to measure the amount of pollutants in fatty tissues of organisms such as fish. In mammals, we often test the milk produced by females, since the milk has a lot of fat in it are often more susceptible to damage from toxins (poisons).
- If a pollutant is not active biologically, it may biomagnify, but we really don't worry about it much, since it probably won't cause any problems Examples: DDT.

### Biotic interaction

Organisms living in this earth are interlinked to each other in one way or other.

The interaction between the organisms is fundamental for its survival and functioning of ecosystem as a whole.

Biotic Interaction			
S.No.	Type	Spices 1	Species 2
1.	Mutualism	(+)	(+)
2.	Commensalism	(+)	(o)
3.	Amensalism	(-)	(o)
4.	Competition	(-)	(-)
5.	Predation	(+)	(-)
6.	Parasitism	(+)	(-)
(+) Benefited (-) Harmed			
(o) Neither Benefited nor harmed.			

### Types of biotic interaction

**Mutualism:** both species benefit.

Example: in pollination mutualisms, the pollinator gets food (pollen, nectar), and the plant has its pollen transferred to other flowers for cross-fertilization (reproduction).

**Commensalism:** one species benefit, the other is unaffected.

Example: Cattle and Cattle Egret

**Competition:** both species are harmed by the interaction.

Example: When two or more organisms in the same community seek the same resource (e.g., food, water, nesting space, ground space), which is in limiting supply to the individuals seeking it, they compete with one another.

If the competition is among members of the same species, it is called intraspecific. Competition among individuals of different species it is referred to as interspecific competition.

Individuals in populations experience both types of competition to a greater or lesser degree.

**Amensalism:** One species is harmed, the other is unaffected.

Example: A large tree shades a small plant, retarding the growth of the small plant. The small plant has no effect on the large tree.

**Predation:** one species benefit, the other is affected.

Example: Lion and Zebra, Fox and Rabbit.

**Parasitism:** one species benefit, the other is affected.

Example: Fleas or ticks that live on dogs and cats

**Neutralism:** There is no net benefit or harm to either species. Perhaps in some interspecific interactions, the costs and benefits experienced by each partner are exactly the same so that they sum to zero. It is not clear how often this happens in nature.

Neutralism is also sometimes described as the relationship between two species inhabiting the same space and using the same resources, but that have no effect on each other. In this case, one could argue that they aren't interacting at all.

**Symbiotic:** Symbiosis is a close relationship between two species in which at least one species benefits.

For the other species, the relationship may be positive, negative, or neutral.

### **Bio-geo-chemical cycle**

The living world depends upon the energy flow and the nutrients circulation that occurs through ecosystem.

Both influence the abundance of organisms, the metabolic rate at which they live, and the complexity of the ecosystem.

Energy flows through ecosystems enabling the organisms to perform various kinds of work and this energy is ultimately lost as heat forever in terms of the usefulness of the system.

On the other hand, nutrients of food matter never get used up. They can be recycled again and again indefinitely.

For e.g. when we breathe we may be inhaling several million atoms of elements that may have been inhaled by our ancestors or other organisms.

Carbon, hydrogen, oxygen, nitrogen and phosphorus as elements and compounds make

up 97% of the mass of our bodies and are more than 95% of the mass of all living organisms.

In addition to these about 15 to 25 other elements are needed in some form for the survival and good health of plants and animals.

These elements or mineral nutrients are always in circulation moving from non-living to living and then back to the non-living components of the ecosystem in a more or less circular fashion.

This circular fashion is known as biogeochemical cycling (bio for living; geo for atmosphere).

### **Nutrient Cycling**

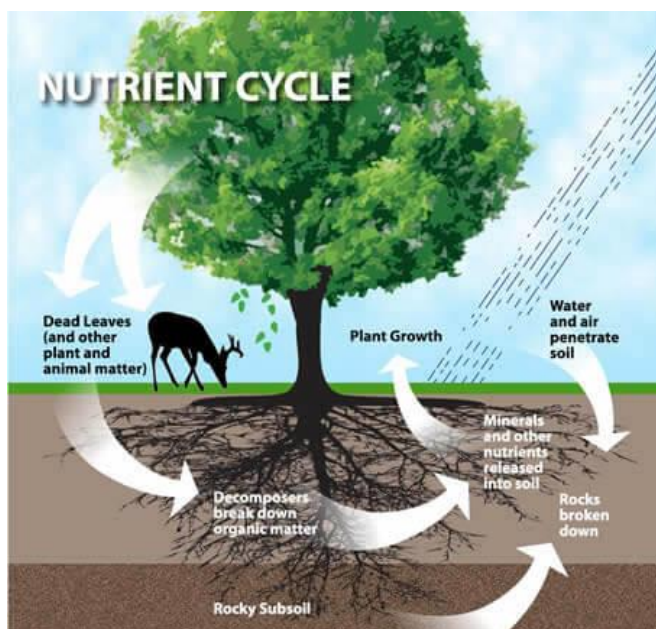
The nutrient cycle is a concept that describes how nutrients move from the physical environment to the living organisms, and subsequently recycled back to the physical environment.

This movement of nutrients from the environment into plants and animals and again back to the environment is essential for life and it is the vital function of the ecology of any region.

In any particular environment, to maintain its organism in a sustained manner, the nutrient cycle must be kept balanced and stable.

Nutrient cycling is typically studied in terms of specific nutrients, with each nutrient in an environment having its own particular pattern of cycling.

Among the most important nutrient cycles are the carbon nutrient cycle and the nitrogen nutrient cycle. Both of these cycles make up an essential part of the overall soil nutrient cycle.



## Types of Nutrient Cycle

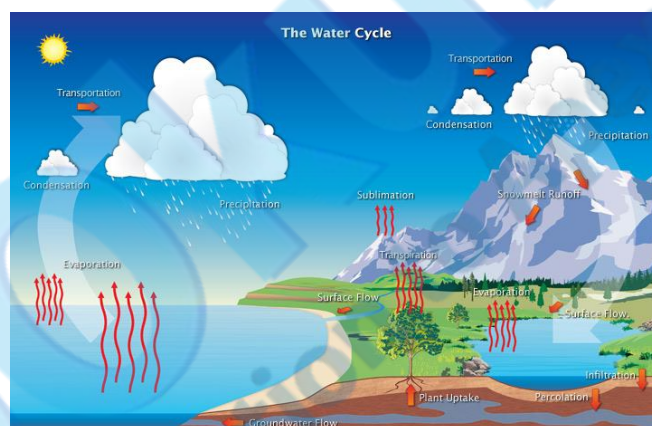
- Based on the replacement period a nutrient cycle is referred to as Perfect or Imperfect cycle.
- A perfect nutrient cycle is one in which nutrients are replaced as fast as they are utilised. Most gaseous cycles are generally considered as perfect cycles.
- In contrast sedimentary cycles are considered relatively imperfect, as some nutrients are lost from the cycle and get locked into sediments and so become unavailable for immediate cycling.
- Based on the nature of the reservoir, there are two types of cycles namely Gaseous and sedimentary cycle
  - **Gaseous Cycle** – where the reservoir is the atmosphere or the hydrosphere, and
  - **Sedimentary Cycle** – where the reservoir is the earth's crust.

## Gaseous Cycles

### Water Cycle (Hydrologic)

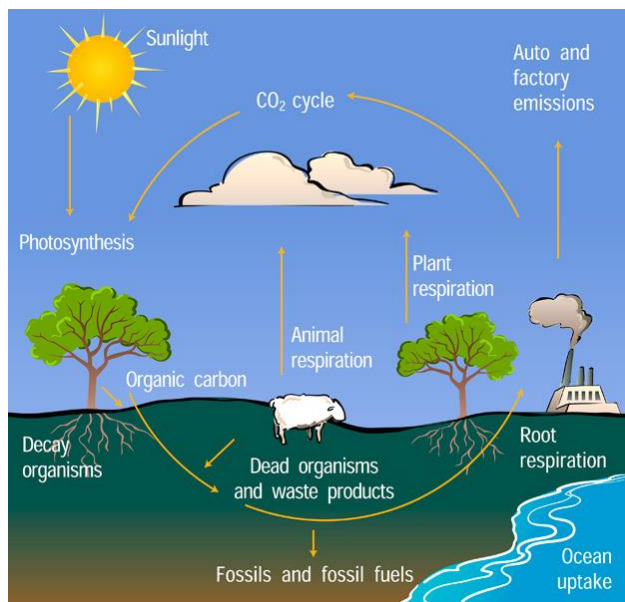
- Water as an important ecological factor that determines the structure and function of the ecosystem.
- Cycling of all other nutrients is also dependent upon water as it provides their transportation during the various steps.
- It acts as a solvent medium for their uptake of nutrients by organisms.

- The hydrologic cycle is the continuous circulation of water in the Earth-atmosphere system which is driven by solar energy.
- Water on our planet is stored in major reservoirs like atmosphere, oceans, lakes, rivers, soils, glaciers, snowfields, and groundwater.
- Water moves from one reservoir to another by the processes of evaporation, transpiration, condensation, precipitation, deposition, runoff, infiltration, and groundwater flow.



## The Carbon Cycle

- Carbon is a minor constituent of the atmosphere as compared to oxygen and nitrogen.
- However, without carbon dioxide life could not exist, because it is vital for the production of carbohydrates through photosynthesis by plants.
- It is the element that anchors all organic substances from coal and oil to DNA (deoxyribonucleic acid: the compound that carries genetic information).
- Carbon is present in the atmosphere, mainly in the form of carbon dioxide (CO<sub>2</sub>).
- Carbon cycle involves a continuous exchange of carbon between the atmosphere and organisms.
- Carbon from the atmosphere moves to green plants by the process of photosynthesis, and then to animals.
- By process of respiration and decomposition of dead organic matter it returns back to atmosphere.
- It is usually a short-term cycle.



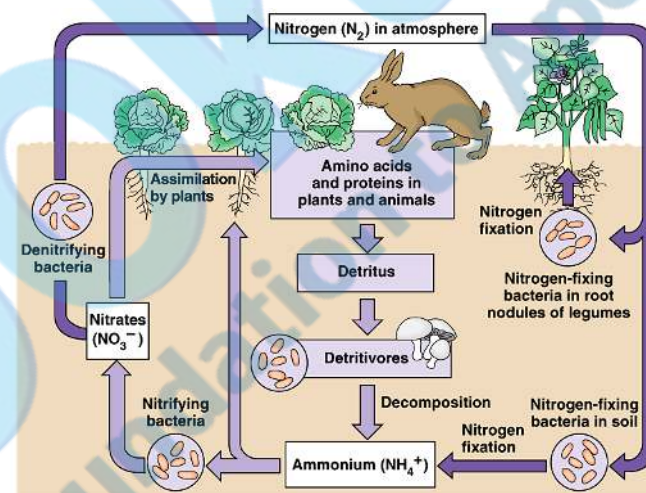
- Some carbon also enters a long-term cycle.
- It accumulates as undecomposed organic matter in the peaty layers of marshy soil or as insoluble carbonates in bottom sediments of aquatic systems which take a long time to be released.
- In deep oceans such carbon can remain buried for millions of years till geological movement may lift these rocks above sea level.
- These rocks may be exposed to erosion, releasing their carbon dioxide, carbonates and bicarbonates into streams and rivers.
- Fossil fuels such as coals, oil and natural gas etc. are organic compounds that were buried before they could be decomposed and were subsequently transformed by time and geological processes into fossil fuels.
- When they are burned, the carbon stored in them is released back into the atmosphere as carbon-dioxide.

### The Nitrogen Cycle

- Nitrogen is an essential constituent of protein and is a basic building block of all living tissue.
- It constitutes nearly 16% by weight of all the proteins.
- There is an inexhaustible supply of nitrogen in the atmosphere but the elemental form cannot be used directly by most of the living organisms.
- Nitrogen needs to be 'fixed', that is, converted to ammonia, nitrites or nitrates, before it can be taken up by plants.

- Nitrogen fixation on earth is accomplished in three different ways:
- By microorganisms (bacteria and blue-green algae)
- By man using industrial processes (fertilizer factories) and
- To a limited extent by atmospheric phenomenon such as thunder and lightning

*The amount of Nitrogen fixed by man through industrial process has far exceeded the amount fixed by the Natural Cycle. As a result, Nitrogen has become a pollutant which can disrupt the balance of nitrogen. It may lead to Acid rain, Eutrophication and Harmful Algal Blooms.*



Certain microorganisms are capable of fixing atmospheric nitrogen into ammonium ions.

These include free living nitrifying bacteria (e.g. aerobic Azotobacter and anaerobic Clostridium) and symbiotic nitrifying bacteria living in association with leguminous plants and symbiotic bacteria living in non leguminous root nodule plants (e.g. Rhizobium) as well as blue green algae (e.g. Anabaena, Spirulina).

Ammonium ions can be directly taken up as a source of nitrogen by some plants, or are oxidized to nitrites or nitrates by two groups of specialised bacteria: Nitrosomonas bacteria promote transformation of ammonia into nitrite.

Nitrite is then further transformed into nitrate by the bacteria Nitrobacter.

The nitrates synthesised by bacteria in the soil are taken up by plants and converted into amino acids, which are the building blocks of proteins.

These then go through higher trophic levels of the ecosystem. During excretion and upon the death of all organisms nitrogen is returned to the soil in the form of ammonia.

Certain quantity of soil nitrates, being highly soluble in water, is lost to the system by being transported away by surface run-off or ground water.

In the soil as well as oceans there are special denitrifying bacteria (e.g. *Pseudomonas*), which convert the nitrates/nitrites to elemental nitrogen.

This nitrogen escapes into the atmosphere, thus completing the cycle.

The periodic thunderstorms convert the gaseous nitrogen in the atmosphere to ammonia and nitrates which eventually reach the earth's surface through precipitation and then into the soil to be utilized by plants.

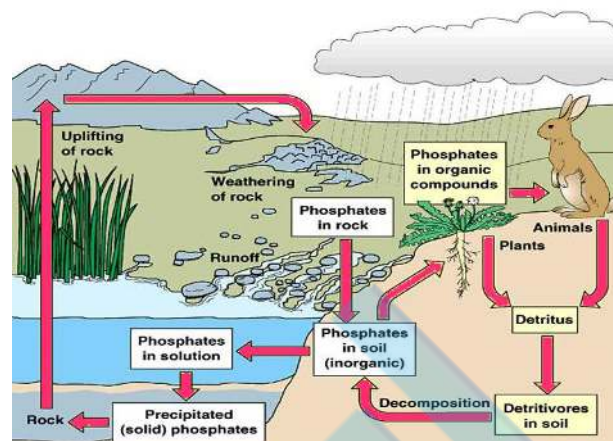
### Sedimentary Cycle

Phosphorus, calcium and magnesium circulate by means of the sedimentary cycle.

The element involved in the sedimentary cycle normally does not cycle through the atmosphere but follows a basic pattern of flow through erosion, sedimentation, mountain building, volcanic activity and biological transport through the excreta of marine birds.

### Phosphorus Cycle

- Phosphorus plays a central role in aquatic ecosystems and water quality.
- Unlike carbon and nitrogen, which come primarily from the atmosphere, phosphorus occurs in large amounts as a mineral in phosphate rocks and enters the cycle from erosion and mining activities.
- This is the nutrient considered to be the main cause of excessive growth of rooted and free-floating microscopic plants in lakes.

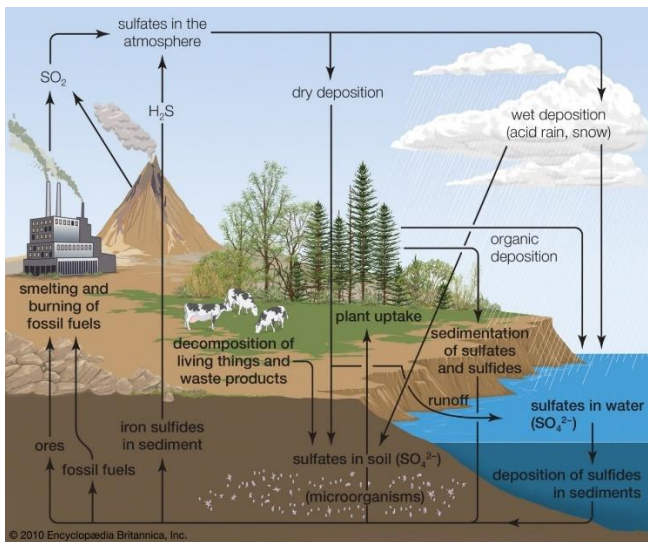


- The main storage for phosphorus is in the earth's crust.
- On land phosphorus is usually found in the form of phosphates.
- By the process of weathering and erosion phosphates enter rivers and streams that transport them to the ocean.
- In the ocean once the phosphorus accumulates on continental shelves in the form of insoluble deposits.
- After millions of years, the crustal plates rise from the sea floor and expose the phosphates on land.
- After more time, weathering will release them from rock and the cycle's geochemical phase begins again.

### Sulphur Cycle

- The sulphur reservoir is in the soil and sediments where it is locked in organic (coal, oil and peat) and inorganic deposits (pyrite rock and sulphur rock) in the form of sulphates, sulphides and organic sulphur.
- It is released by weathering of rocks, erosional runoff and decomposition of organic matter and is carried to terrestrial and aquatic ecosystems in salt solution.
- The sulphur cycle is mostly sedimentary except two of its compounds hydrogen sulphide ( $H_2S$ ) and sulphur dioxide ( $SO_2$ ) add a gaseous component to its normal sedimentary cycle.
- Sulphur enters the atmosphere from several sources like volcanic eruptions, combustion of fossil fuels, from surface of ocean and from gases released by decomposition.

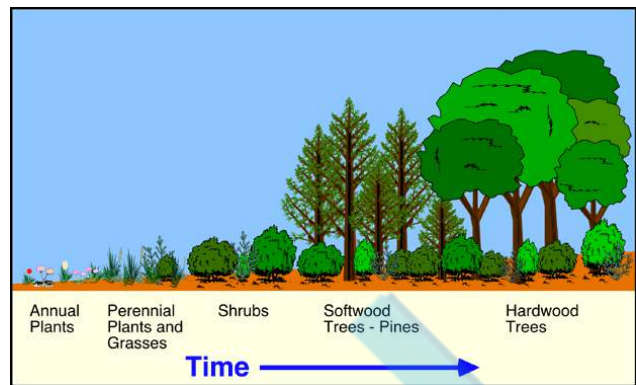




- Atmospheric hydrogen sulphide also gets oxidised into sulphur dioxide.
- Atmospheric sulphur dioxide is carried back to the earth after being dissolved in rainwater as weak sulphuric acid.
- Whatever the source, sulphur in the form of sulphates is taken up by plants and incorporated through a series of metabolic processes into sulphur bearing amino acid which is incorporated in the proteins of autotroph tissues. It then passes through the grazing food chain.
- Sulphur bound in living organism is carried back to the soil, to the bottom of ponds and lakes and seas through excretion and decomposition of dead organic material.

### Ecological succession

- Succession is a universal process of directional change in vegetation, on an ecological time scale.
- Succession occurs when a series of communities replace one another due to large scale destruction either natural or manmade.
- This process continues - one community replacing another community, until a stable, mature community develops.
- Succession is a progressive series of changes which leads to the establishment of a relatively stable climax community.



- The first plant to colonise an area is called the pioneer community.
- The final stage of succession is called the climax community.
- The stage leading to the climax community are called successional stages or seres.

A seral community (or sere) is an intermediate stage found in ecological succession in an ecosystem advancing towards its climax community.

- Hydrosere: Community in water
- Lithosere: Community on rock
- Psammose: Community on sand
- Xerosere: Community in dry area
- Halosere: Community in saline body

Succession is characterised by the following: increased productivity, the shift of nutrients from the reservoirs, increased diversity of organisms with increased niche development, and a gradual increase in the complexity of food webs.

### Primary Succession

- In primary succession on a terrestrial site the new site is first colonized by a few hardy pioneer species that are often microbes, lichens and mosses.
- The pioneers over a few generations alter the habitat conditions by their growth and development.
- These new conditions may be conducive to the establishment of additional organisms that may subsequently arrive at the site.
- The pioneers through their death and decay leave patches of organic matter in which small animals can live.
- The organic matter produced by these pioneer species produces organic acids

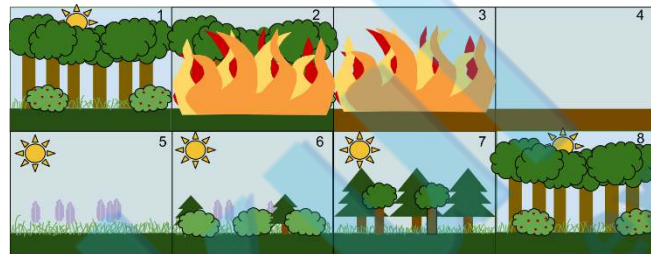
during decomposition that dissolve and etch the substratum releasing nutrients to the substratum.

- Organic debris accumulates in pockets and crevices, providing soil in which seeds can become lodged and grow.
- As the community of organisms continues to develop, it becomes more diverse and competition increases, but at the same time new niche opportunities develops.
- The pioneer species disappear as the habitat conditions change and invasion of new species progresses, leading to the replacement of the preceding community.

### Secondary Succession

- Secondary succession occurs when plants recognize an area in which the climax community has been disturbed.
- Secondary succession is the sequential development of biotic communities after the complete or partial destruction of the existing community. A mature or intermediate community may be destroyed by natural events such as floods, droughts, fires, or storms or by human interventions such as deforestation, agriculture, overgrazing, etc.
- This abandoned farmland is first invaded by hardy species of grasses that can survive in bare, sun-baked soil.
- These grasses may be soon joined by tall grasses and herbaceous plants.
- These dominate the ecosystem for some years along with mice, rabbits, insects and seed-eating birds.

- Eventually, some trees come up in this area, seeds of which may be brought by wind or animals.
- And over the years, a forest community develops.
- Thus, an abandoned farmland over a period becomes dominated by trees and is transformed into a forest.



The differences between primary and secondary succession, the secondary succession starts on a well-developed soil already formed at the site.

Thus, secondary succession is relatively faster as compared to primary succession which may often require hundreds of years.

### Autogenic and Allogenic Succession

When succession is brought about by living inhabitants of that community itself, the process is called autogenic succession, while change brought about by outside forces is known as allogenic succession.

### Autotrophic and Heterotrophic succession

Succession in which, initially the green plants are much greater in quantity is known as autotrophic succession; and the ones in which the heterotrophs are greater in quantity is known as heterotrophic succession.