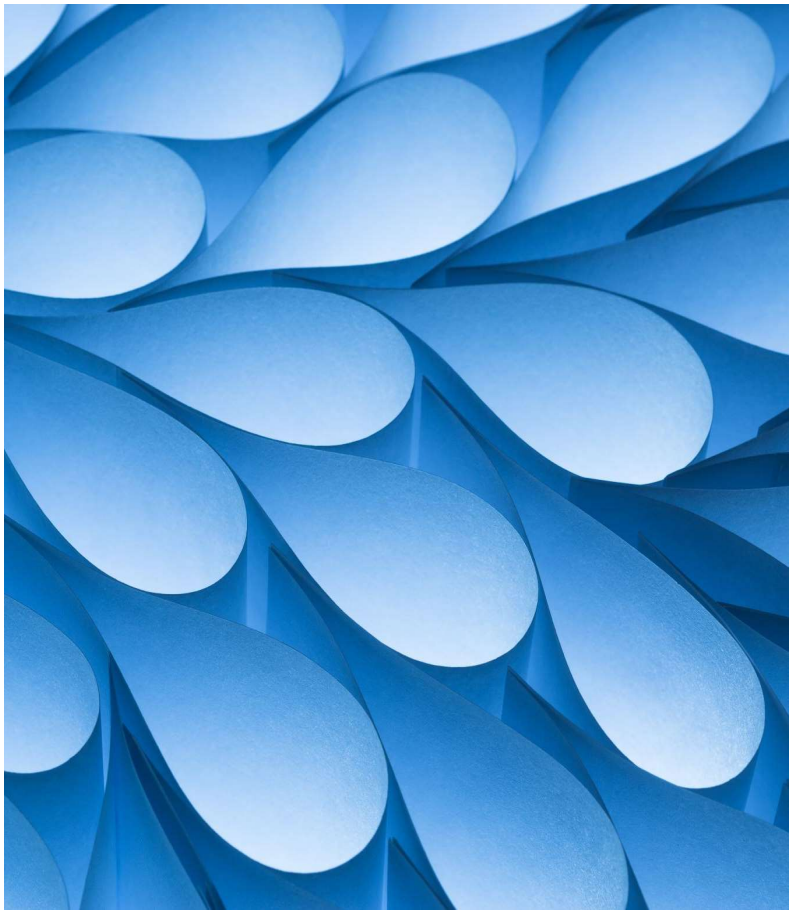
Applied Science and Humanities Department

MATHEMATICS |CHEMISTRY | PHYSICS | HUMANITIES | MANAGEMENT | SPORTS

DR. MAYANK M DALAL

ASSOCIATE PROFESSOR, CHEMISTRY SECTION

ENVIRONMENTAL SCIENCE



ENVIRONMENT, ECOLOGY & ECOSYSTEM

DR. M. M. DALAL

ASSOCIATE PROFESSOR,

CHEMISTRY SECTION ASH DEPT.

SCET, SURAT

ENVIRONMENTAL SCIENCE

- DEFINITION,
- CONCEPTS OF ECOSYSTEM- STRUCTURES AND FUNCTIONS
- FOOD CHAIN AND FOOD WEB
- ENERGY FLOW IN ECOSYSTEM
- ECOLOGICAL PYRAMIDS, BIODIVERSITY CONSERVATION (IN SITU-EX SITU)
- BIOGEOCHEMICAL CYCLES- NITROGEN AND HYDROLOGICAL CYCLE.

DR. M. M. DALAL

ASSOCIATE PROFESSOR,

CHEMISTRY SECTION ASH DEPT.

SCET, SURAT

Introduction to Environmental Science

The word **Environment** is derived from the French word "Environ" which means "surrounding".

It includes all the biological and non-biological things surrounding an organism.

The biologist Jacob Van Uerkal (1864-1944) introduced the term 'environment' in Ecology. Ecology is the study of the interactions between an organism of some kind and its environment.

Environment is the sum total of inter relationships that exist among living organism.

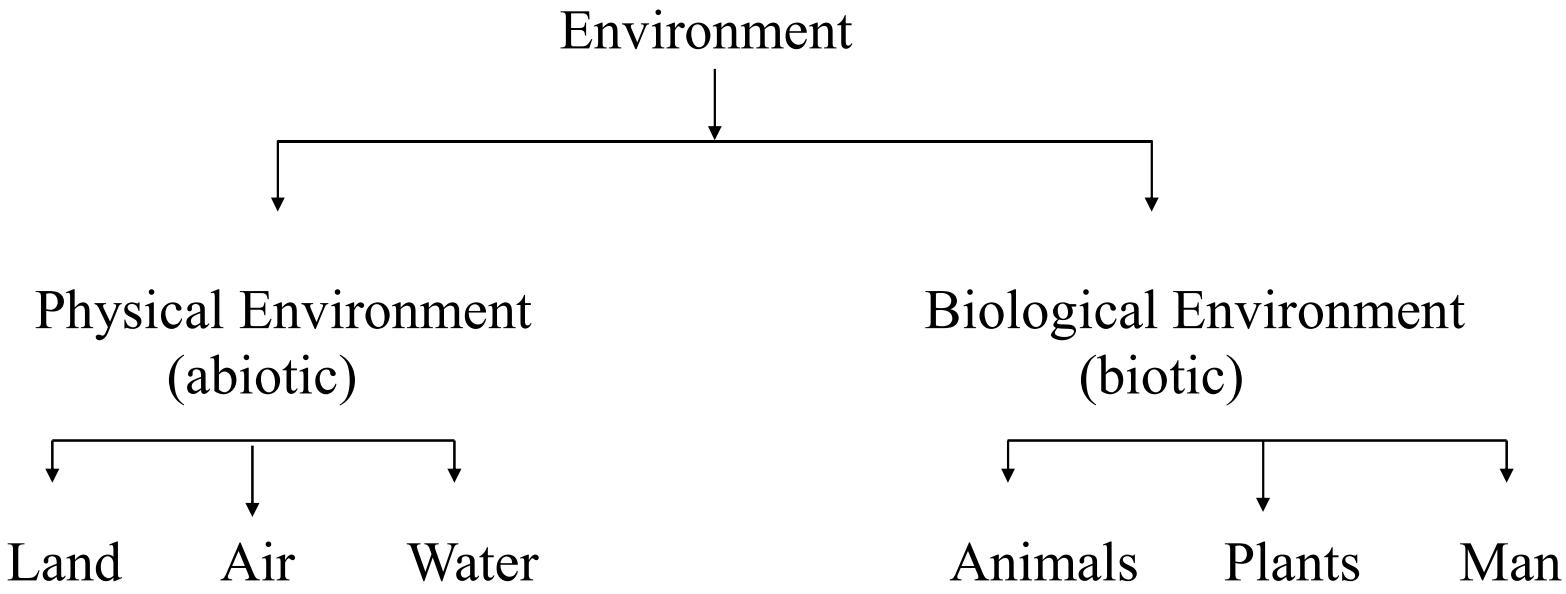
Environmental science is the study of the interaction of humans with the natural environment.

The term **Environment** refers to surrounding, include both living and non-living components.

Classification of Environment

Environment is composed of physical and biological components.

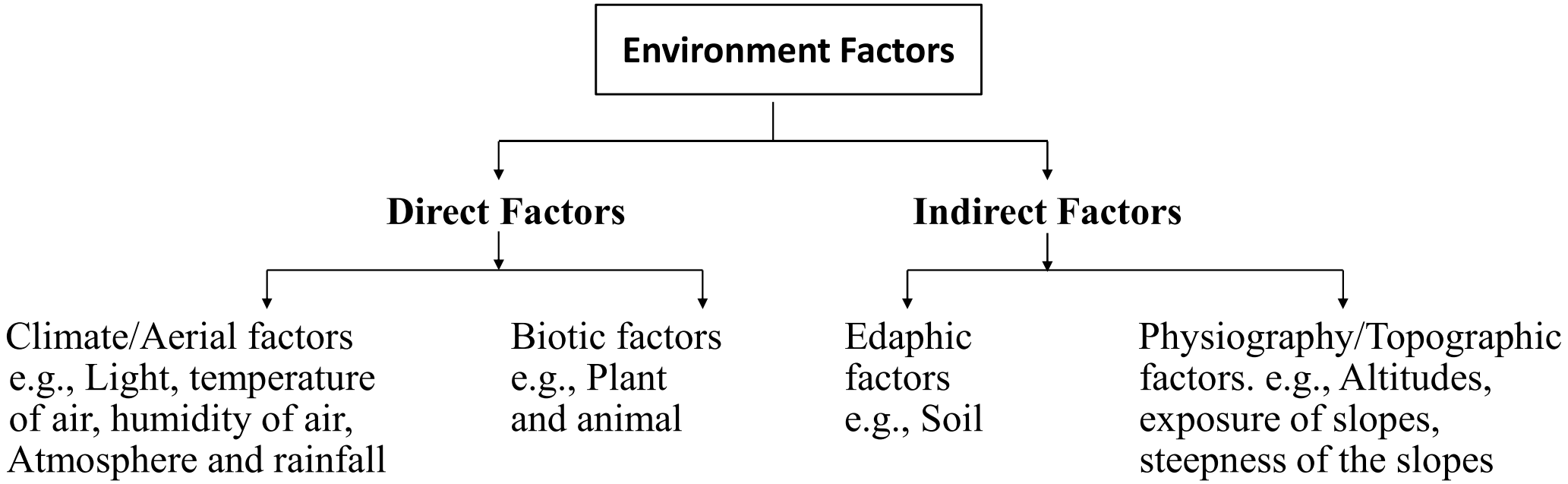
It includes both living and non-living component.



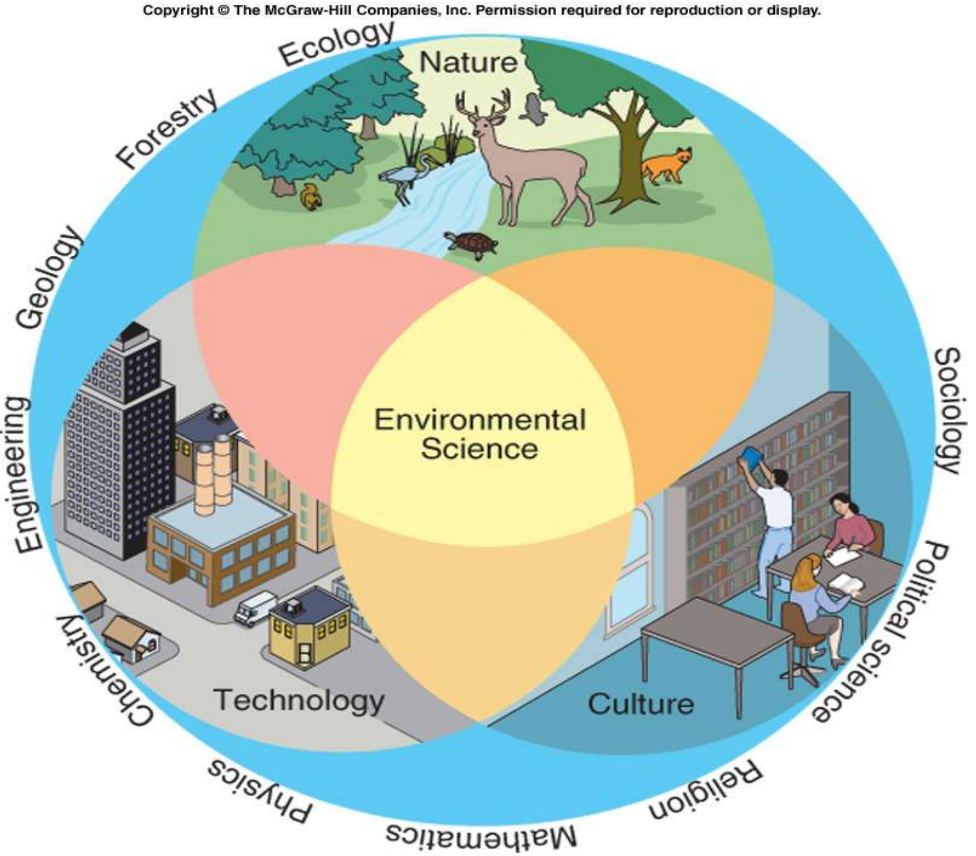
Environmental factors

Various factors of environment have been grouped and discussed in different ways. All factors are classified into two groups:

i) Direct factor and ii) Indirect factor



Scope of Environmental Science



Scope of Environmental Science

It has a scope in large number of areas and aspects which can be summarized as follows:

1. Natural resources- their conservation and management
2. Ecology and biodiversity
3. Environmental pollution and control
4. Social issues in relation to development and environment
5. Human population and environment

Scope of Environmental Science

- A community decides to use coal for electricity, as it is the cheapest source available. **(Economics)**
- The coal must be mined from under the soil. ***(Geology)***
- The coal must be transported to the population center by road or rail. **(Engineering)**
- When it is burned at a power plant, air pollution is released. Some of that pollution is converted to acid in the atmosphere. **(Chemistry)**
- This falls as acid rain somewhere downwind. **(Meteorology)**
- The acid stresses plants by affecting their nutrient absorption. **(Ecology)**

Components of Environment

Environment can be divided into four components

1) Atmosphere
2) Hydrosphere
3) Lithosphere
4) Biosphere

Atmosphere

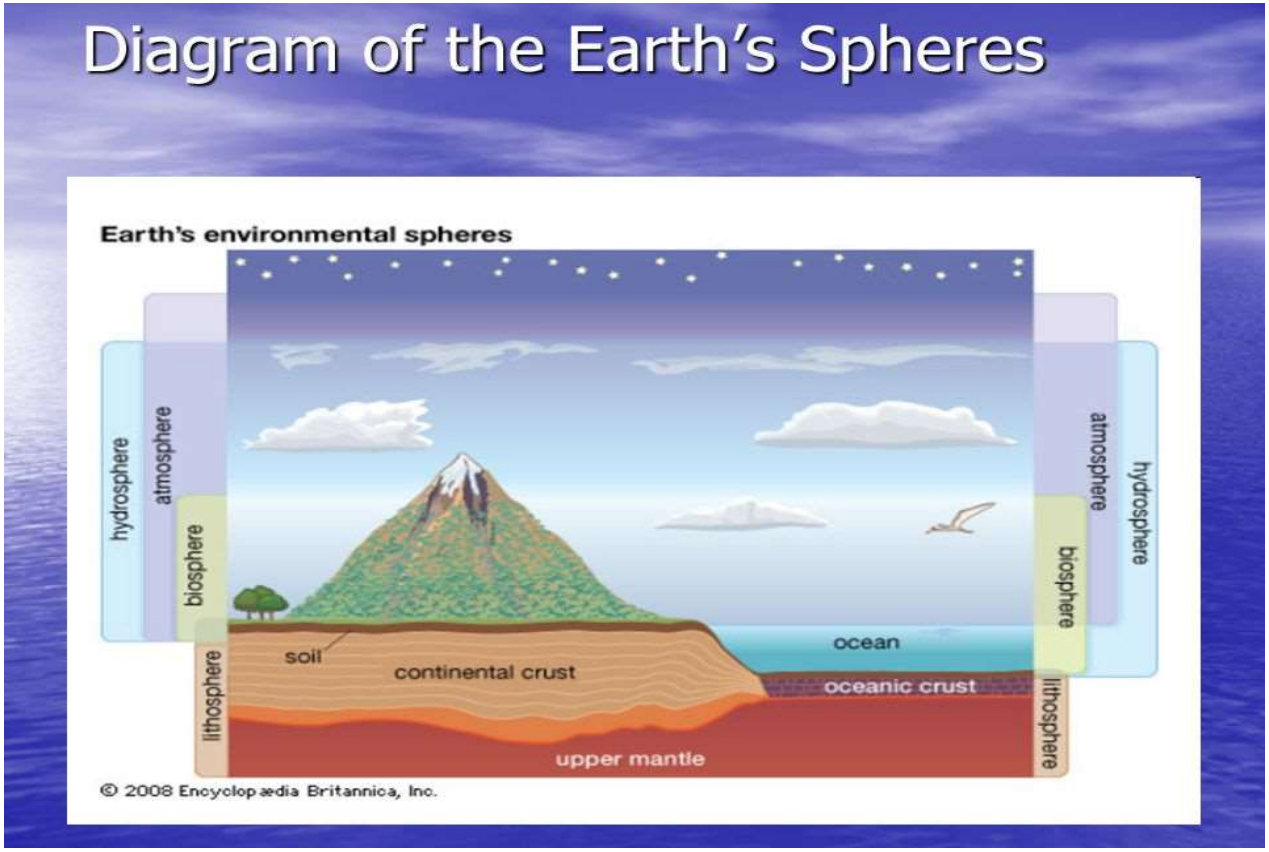


Diagram of the Earth's Spheres
Earth's environmental spheres
hydrosphere
atmosphere
biosphere
lithosphere
soil
continental crust
ocean
oceanic crust
upper mantle
atmosphere
hydrosphere
biosphere
lithosphere
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Atmosphere

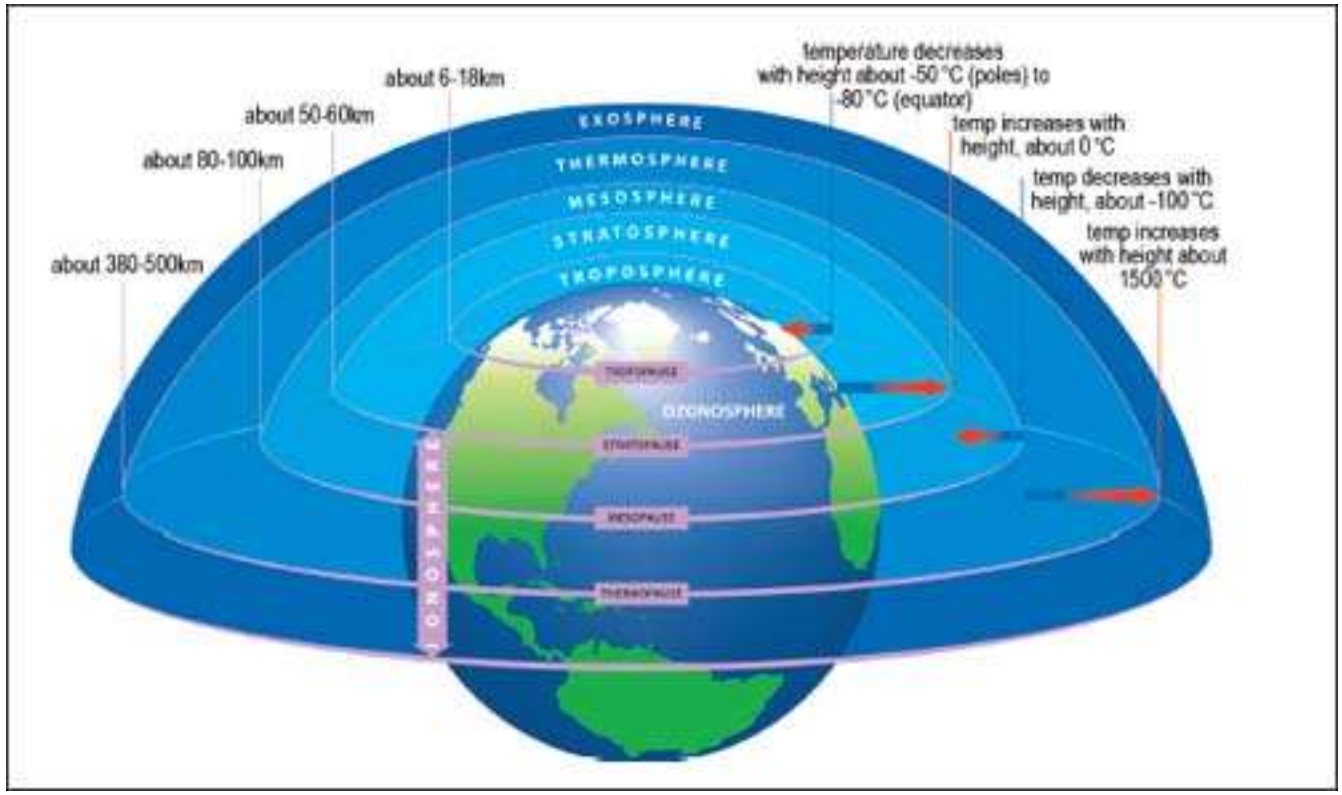
It is a thin envelope of air around the earth extending to about 80 km above its surface. It is a very important layer on the earth surface and life on earth is not possible without the atmosphere.

It works as protective layer and gives us oxygen, maintains the temperature and sunlight to live.

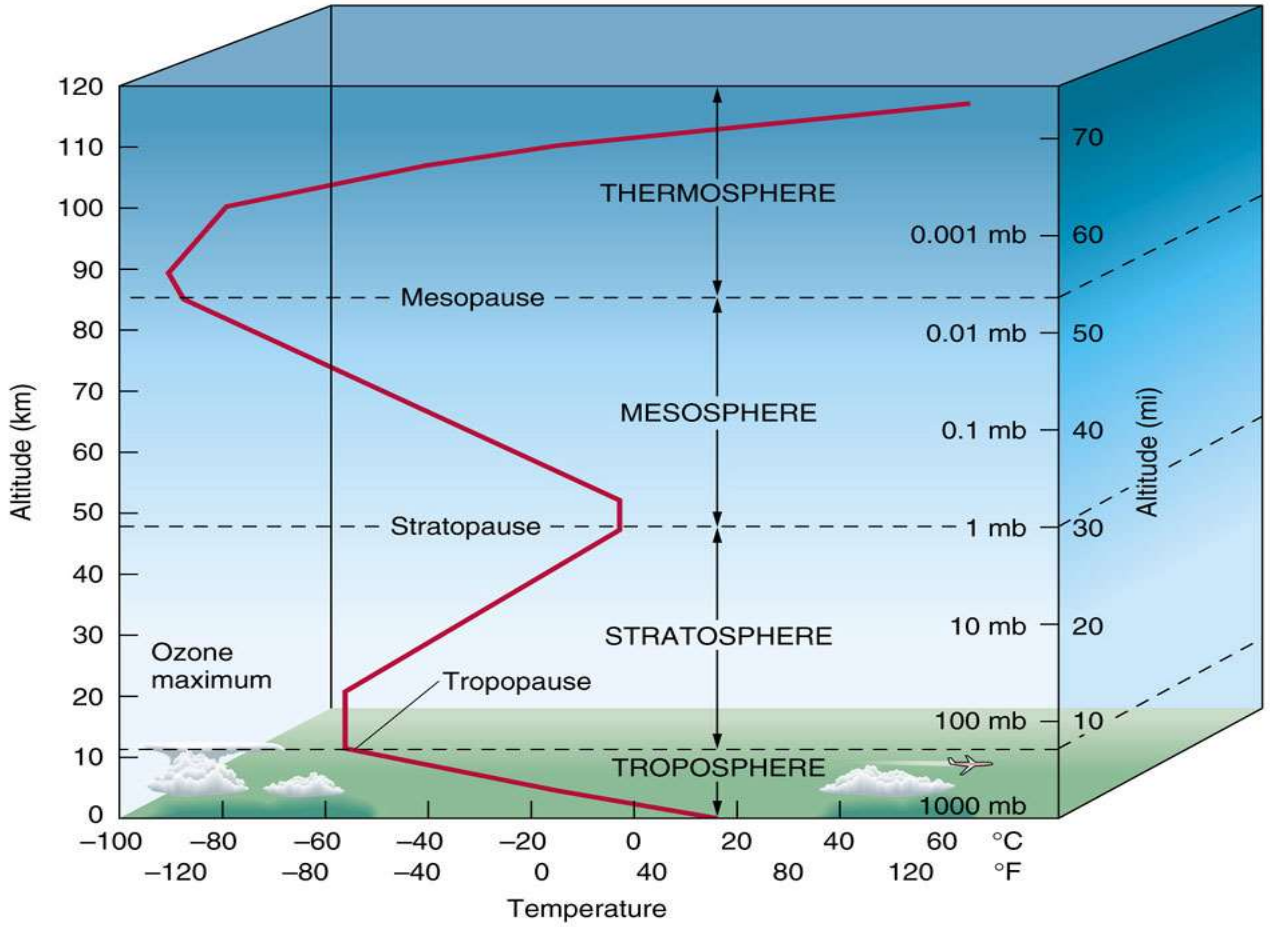
No	Name of the part	Height in km from earth surface	Temperature in ^{o}C
1.	Troposphere (covers (90% of Atmosphere)	0 -11	15 to -55
2.	Stratosphere	11-50	-2 to -55
3.	Mesosphere	56-85	-2 to -92
4.	Thermosphere	85-100	-92 to 1200

- Above the troposphere is the stratosphere that contains ozone. It is the ozone that supports life by filtering out the harmful UV Radiation from the sun.
- Hydrosphere consists of the liquid water, ice and water vapour.
- Lithosphere is the earth's upper crust containing fossil fuels and minerals.
- Biosphere includes most of the hydrosphere and parts of the lower atmosphere and upper lithosphere.

Atmosphere


about 6-18km
about 50-60km
about 80-100km
about 380-500km
temperature decreases with height about -50 °C (poles) to -80 °C (equator)
temp increases with height, about 0 °C
temp decreases with height, about -100 °C
temp increases with height about 1500 °C
EXOSPHERE
THERMOSPHERE
MESOSPHERE
STRATOSPHERE
TROPOSPHERE
OZONOSPHERE
IONOSPHERE

Structure of Atmosphere



Structure of Atmosphere

Atmosphere is divided into five major layers.

1. Troposphere:

Troposphere is the lower portion of the atmosphere which extends up to 8 km at the poles and 16 km at equator.

Average it extends up to 10-11 km from the earth surface.

The temperature decreases at the rate of 5-7^{o}C/km.

2. Stratosphere:

It is above troposphere and extend up to 50-55 km.

Up to 20 km temperature remains constant then increase with increase in height. Ozone layer is in this layer.

Structure of Atmosphere

3. Mesosphere:

It is the layer above stratosphere and extends up to 80 km.

Here temperature decrease slowly with altitude but then sharply to about -75^{o}C.

4. Thermosphere:

Temperature increases rapidly with increase in height.

The heating of tis layer is due to absorption of solar energy.

Within the thermosphere there is a layer of charged particles known as ionosphere.

5. Exosphere:

It exist above ionosphere and extends up to 2000 km above the earth. It has very high temperature (≥1200^{o}C)

Hydrosphere

- It covers more than two-thirds of the Earth's surface.
- About 70% of earth is covered by water.
- Clean and Sweet water represents less than 0.5% of the total water on the earth.
- The rest is in the form of the seawater (about 96%) or locked up in icecaps (about 2.5%) or the soil (about 0.5%), which are not useful for any suitable purpose except soil water.
- It is estimated that hydrosphere contain about 1360 million cubic km of water out of which 97% is in the ocean and sea, 2% in glaciers and ice caps while remaining 1% of fresh water is available for human consumption.

Lithosphere

- The outer soil crust of the earth is lithosphere.
- It covers most part of the earth surface (crust) in form of the hills, grassland, deserts etc. i.e. different type of soil/rock fragmentation.
- The lithosphere includes all the metals, minerals, inorganic and organic matter present in the soil.
- This minerals are very useful to green vegetation and ultimately to the entire living organism as they are the basic element in food cycle.
- Some part of the air and water is also considered as part of the lithosphere for e.g. as soil has porous structure some of the air is present in its pores or when saturated some water is present in the pores.
- The living organisms, plant and vegetation are supported by the lithosphere.
- It also contain resources like minerals, organic as well as inorganic matter and to some extent air and water.
- Lithosphere plays an important role as it not only produces food for human beings and animals, but also the decomposition of organic wastes is carried out by a host of microorganisms in the soil.

Biosphere

- It is the part of the earth where the life exists and the supporting environment for this life.
- It is where all the living organisms interact with each other, and with their environment.
- Thus it is that portion of the planet and its environment that's support life.
- Every living organism is getting the all basic resources from the biosphere i.e. air, water, food and sunlight etc. and simultaneously the waste in form of solid/liquid or gases produced by it are also discharged in to the biosphere.
- Thus, Biosphere has a capacity to absorb, convert or dilute the waste and make it useful once again to the next generation of organism.
- UNESCO has initiated the Man and the Biosphere program in 1971 which contains three zone,
- **Core area** : Fragile, conserve and legally protected, except research and monitoring.**Buffer Zone – 1**: Non destructive research, agriculture, education, recreation, sustainable logging, grazing, hunting, fishing permitted.
- **Buffer Zone – 2**: Transition zone in which conservation could be combined with more intensive and yet sustainable above activities is carried out.
- Total 531 biosphere reserves are their in 105 countries.

Ecology

The scientific study of the interaction of organisms with their physical environment and with each other is called ecology.

The ecology deals with study of species in their habitat interacting with their surroundings.

Objectives:

- To study inter-relationship between different group of organism.
- To study natural behavior of organism in different environmental (seasonal) condition and temporal (ecological succession)
- To study the change in structural adoptions and functional behavior according to their physical environment.
- To study hierarchy of evolution pattern.
- To develop mathematical model to co-relate interaction of different parameter and to predict its effect to environment.
- To conserve ecology of living organism.

Classification:

- According to Ecologist, Ecology can be classified as,
  - Autecology (Specific Ecology)
  - Synecology (Community Ecology)
    - Population Ecology
    - Community Ecology
    - Ecosystem Ecology

Ecology

Autecology:

- The autecology is study of individual species/orgnaism and its population. Moreover, the behaviour to adopt different environmental condition in their life cycle can be studied in autecology.

Synecology:

- The synecology is study of ecology for community, their interrelationship, composition and its behaviour in the environment.

Classification on the basis of their habitation:

- Aquatic Ecology:
  - Marine
  - Stream
  - River
  - Estuaries
- Terrestrial Ecology:
  - Grassland
  - Forest
  - Desert
  - Mountain

Ecosystem

Ecosystem is such define as a living community of plants and animals sharing an environment with non-living elements such as climate and soil.

To study more precisely about an ecosystem few basic terms are to be studied.

- Organisms: It is any living thing-an animal, a plant, or a microbe.
  - Cell is the basic unit of life in organisms.
  - Organism like bacterium made up of a single cell, while most organisms are made up of many cells.
- Species: It is a set of organisms that resemble one another in appearance and behaviour.
  - Organisms are capable enough to reproducing naturally among themselves.
  - Organism of different species do not interbreed and, even if they do, they do not produce fertile offspring.
- Population: The member of a species living and interacting within a specific geographical region are together called a population.
  - Neem trees in a forest, people in a country, goldfish in a pond.
  - Diversity is always exist in most natural population.

Ecosystem

- Though there are broad similarities among the members within the population they do not all look exactly alike and they do not all behave in the same way.

- Thus the term population refers only to those members of a certain species that live within a given area.
- The term species includes all members of a certain kind, even if they exist in different populations in widely separated areas.
- Community (Biocenose): It is the collection of all the interacting populations of different species existing in a geographical area.
  - It is a complex interacting network of plants, animals and microorganisms.
  - Population plays a defined role in the community.
  - Each population is the result of procreations between individuals of the same species and cohabitation in a given place and for a given time.
  - When a population consists of an insufficient number of individuals, that population is threatened with extinction; the extinction of a species can approach when all biocenoses composed of individuals of the species are in decline.
  - In small populations, consanguinity (inbreeding) can result in reduced genetic diversity, which can further weaken the biocenose.
- Thus,
- Ecosystem is a community of living organisms (populations of species) interacting with one another and with the non-living physical and chemical environment.

Classification of an Ecosystem

1. Natural and Artificial Ecosystems	
Natural	Naturally occurring for e.g. Forest, Pond etc.
Artificial	Man made e.g. Garden, Zoo, Aquarium etc.

2. Terrestrial and Aquatic Ecosystems	
Terrestrial	Existing on the land for e.g. forest, desert, grassland etc.
Aquatic	Existing in water for e.g. Pond, River, Ocean etc.

3. Incomplete Ecosystems

- According to the Southwick (1976), those ecosystems that do not contain all the four basic components, i.e. Abiotic substances, Producers, Consumers, Decomposers are called as Incomplete Ecosystems.
- Example : Abyssal depth of the sea and caves lack producers but contain only the consumers and decomposers.

Ecosystem

Important characteristics of ecosystem:

- The ecosystem changes as time passes.
- The ecosystem is the system where energy and nutrient flows.
- The ecosystem may be natural (river, lake) or artificial (wet land, agricultural field).
- In ecosystem, each abiotic and biotic component transfer energy from one level to another level.
- The basic component on which ecosytem rest is production of organic matter, by process of photosynthesis.
- The ecosystem does not have definite size e.g. tropical rain forest covers larger area whereas; pond covers small area so both have different size.

Structure of an Ecosystem

1. Biotic Component (Living)

- It consist of all the species inhabiting in an area.
- It includes plants, animals and microorganisms.
- Biotic community interact with each other and with the abiotic conditions in such a way as to perpetuate the species.
- Species in community are mutually dependent in many ways.
- **Example** : In forest ecosystem, the bird eat fruits from the trees and build their nests on them. The birds in turn spread the plant seeds, helping the propagation of the tree species.

2. Abiotic Component (Non living)

- It is a nonliving community.
- The abiotic conditions both support and limit the biotic community.
- The abiotic condition of terrestrial ecosystems include water, air, soil, nutrients, minerals, salinity and acidity levels, energy, sunlight, temperature, wind, rainfall and climate. Also the latitude and altitude of the area and the frequency of fires.
- In aquatic ecosystems, the abiotic conditions include the depth turbidity, salinity and temperature of the water, chemical nutrients, suspended solids, currents and the texture of the bottom (rocky or silty).

Boundary of an Ecosystem

Where the Sea ends and the Land start?

What is the boundary line between a forest and the adjoining grassland?

- Natural ecosystem rarely have distinct boundaries.
- They are never truly self- contained and self-sustaining system.

Ecotone : It is a transitional zone between the two ecosystem. Where one can find the mix species or some other additional species which will not found in other ecosystem. Ecotones could be studied as a distinct ecosystem.

Edge effect : Ecotones may have greater population densities of certain species than in either of the adjoining communities which is called as an edge effect.

Edge effect can be seen at coastal zones, where the land and the ocean meet.

Example: Due to flow of tides, coastal zones do not have fixed boundaries. Due to that it is rich in biological diversity. In such cases it provides habitats for such organisms which can survive in water and on land. **E.g.:** Mangroves, Tortoise etc.

Estuary : It is the area where the river and sea or ocean meets. There is a constant exchange of Salt water and Fresh water due to that biodiversity is very high. **E.g.** Chennai estuary where river Adyar meets the Sea in such zone wide variety of organisms attracts along with wide variety of birds.

Evolution of an Ecosystem

How does an ecosystem get established?

- **Primary Ecological System :**
  - **Example:** There is a growth of moss on rocky surface due to some rain or moisture. Moss becomes mat that hold the soil which is coming in it's way, Seeds will led to grow some plant gradually which holds more soil, further shrubs and trees follows which gradually grows and grows and make it a forest from where moss and small plants may disappear due to littering, further it's place is taken up by big trees. This is a **Primary Ecological System.**
  - This helps other community to grow due to favorable conditions. As the second community moves in and prospers, the conditions may become unfavorable for the first and it may disappear.
- **Climax Ecosystem :**
  - Ecological succession does not go indefinitely. A stage is reached at which all the species are in dynamic equilibrium among themselves and with the environment. This state is called **Climax Ecosystem**.
  - During Ecological succession, one biotic community gradually makes way for another, the second gives way to a third, and so on, until a climax is reached.
  - Climax Ecosystem could also change. If drastic climate changes occur, or species from other ecosystems are introduced into the ecosystem, a process of adaptation and succession follows. Left undisturbed, an ecosystem always moves towards a state of dynamic equilibrium or climax stage.
  - If the original forest ecosystem is cleared somehow and if the same area is left undisturbed then secondary ecological succession takes place. As the old soil is still present, but the microclimate in the clearing is different. The appropriate species from the surrounding will invade the area. Slowly, each biotic community will give way to another until the clearing becomes indistinguishable from the larger ecosystem.

Habitat

A habitat is Latin word means it inhabits.

- It is the area in which a species is biologically adapted to live.
- Habitat of given **Species** or **Population** possess certain specific physical and biological features such as vegetation, climatic conditions, presence of water and moisture, and soil type.
- It is an ecology of environmental area that is inhabited by a particular animal or plant species. It is the natural environment in which an organism lives, or the physical environment that surrounds (influence and is utilized by) a species.
- The term species population is preferred to organism because, while it is possible to describe the habitat of a single black bear, we may not find any particular or individual bear but the grouping of bears that comprise a breeding population and occupy a certain biogeographically area. Further, this habitat could be somewhat different from the habitat of another group or population of black bears living elsewhere. Thus it is neither the species nor the individual for which the term habitat is typically used.
- A microhabitat is a physical location that is home to very small creatures, such as woodlice...

Ecological Niche

(French word –nest) coined first by the naturalist Joseph Grinnell in 1917.

- How do so many species live together in an ecosystem without fierce competition taking place?
- This confirms the presence of Predator-Prey relationship, which does not means the extermination of any species. It is some generation and decomposition relationship which further maintain the ecological balances.
- Thus each species in an ecosystem has found its habitat and, what is more an ecological niche within the habitat.
- Ecological Niche: Means particular food habits, shelter-seeking methods, ways of nesting and reproduction, etc. of the species. All aspects of the organism's existence- Physical, Chemical and Biological factors, where the organisms lives, what it eats, how it interact with other organisms etc……. Are included in this.
- Thus, in Ecology the term Niche describes the relational position of a population or species in its ecosystem. It describes how an organism or population responds to the distribution of resource and competitors and it in turns alter those some factors.

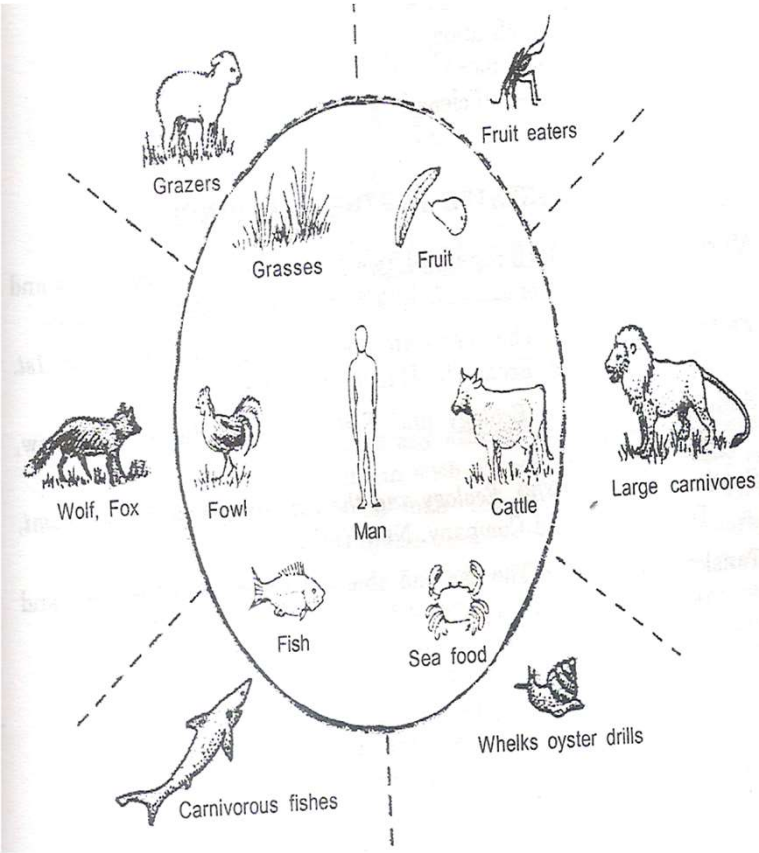
Ecological Niche of a Man

It is characterized in part by man's requirement of foods shown within the circle around man.

These food organisms also happen to form parts of the ecological niches of other animals, as indicated outside the circle, but such animals also use foods not used by man.

Thus, although these niches partly overlap man's, each is nevertheless distinct and characteristic of a particular species.

Ecological niches are defined not only by food organisms but also by geographic territory, waste products, structures, and other species attributes.



Ecosystem- A sustainer of life

Ecosystems vary widely in size, complexity, biotic and abiotic components.

It is true that no individual species or organism or populations cannot sustain life indefinitely.

No single species on this world can produce all the food it needs decompose all its wastes, and reuse the matter to produce more food.

Thus, it is the minimal grouping of diverse organisms that interact and function together in order to sustain life, and it is require to focus on conservation of species and to use the natural resources in a sustainable manner.

Value of an Ecosystem

- Ecosystems are wonders of nature, diversity in living organism and non living really catch ones eyes it is marvelous. What do they do for us? Should we conserve it or we take it as granted.
- We use it like anything without worrying of repayment. It is only due to it the life is existed and sustaining. Let us review what it is giving to us,
  - Maintenance of the biogeochemical cycles.
  - Modification of climates.
  - Waste removal and detoxification.
  - Natural pest and disease control.
  - Erosion control, Soil building, and soil renewal.
  - Energy; resources.
  - Materials like minerals,
  - Air and its purification.
  - Food (plant, animals, fishes etc.)
  - Biodiversity and the gene pool.
  - Renewable resources like forests, wildlife, grasslands, etc.

Functioning of an Ecosystem

All ecosystems maintain themselves in a characteristic dynamic state.

The characteristics of an ecosystem depend on climate, topography, the nature of soil, and the living organisms that inhabit it along with so many interrelationships.

The interaction between the components of ecosystem functioned through the energy and material flow (like N, C, H_2O etc.) .

The function of the ecosystem is to allow flow of energy and cycling of materials which ensures stability of the system and continuity of life.

Two Ecological processes viz. – Energy flow and Materials cycling including interactions between biotic and abiotic environment is the heart of the ecosystem functioning.

It is analyzed in terms of,

- Food chain and Food Web.
- Ecological Pyramids.
- Energy Flow.
- Nutrient cycles.

Producers, Consumers and Decomposers

The leaf is the primary site of photosynthesis in plants.

Producers or *Autotrophs* -- Usually plants or cyanobacteria that are capable of photosynthesis but could be other organisms such as the bacteria near ocean vents that are capable of chemosynthesis.

Consumers or *Heterotrophs* -- Animals, which can be primary consumers (herbivorous), or secondary or tertiary consumers (carnivorous and omnivores).

Decomposers or *Detritivores* -- Bacteria, fungi, and insects which degrade organic matter of all types and restore nutrients to the environment. The producers will then consume the nutrients, completing the cycle.

Producers

The green plants have chlorophyll with the help of which they trap solar

energy and change it into chemical energy of carbohydrates using simple

inorganic compounds namely water and carbon dioxide.

They are Autotrophs. (Auto = Self, Trophos = Feeder)

This process is known as Photosynthesis.

Carbon dioxide + Water + Solar Energy = Sugar + Oxygen.

As the green plants manufacture their own food they are known as Autotrophs. (Auto = self, trophos = feeder).

In Aquatic ecosystem certain Chemosynthesis reaction takes place. Special bacteria convert simple compounds from their environment into more complex nutrient compounds without sunlight but with the help of some geothermal energy (heat which is generated by the decay of radioactive elements).

Examples:

- Chemosynthetic bacteria, Photosynthetic bacteria.
- Algae, Grasses.
- Mosses.
- Shrubs, Herbs, Trees.

Consumers

The animal lack chlorophyll and are unable to synthesis their own food.

They depend on the producers for their food.

Therefore they are known as Heterotrophs. (Hetero = other, trophos = feeder).

The consumers are of four types,

- Primary consumers or First Order Consumers:
  - They are herbivorous feed on plants. E.g. Rabbit, Deer, Goat etc.
- Secondary Consumers or Second Order Consumers:
  - They are Carnivorous feed on herbivorous. E.g. Cats, Foxes, Snakes etc.
- Tertiary Consumers or Third Order Consumers:
  - They are the large Carnivorous which feed on the secondary consumers.

Omnivorous eat both plants and animals and hence they feed at more than one level. Human beings, bears, foxes, pigs, rats and cockroaches.

Decomposers

Bacteria and Fungi belongs to this category.

They breakdown the dead organic materials of producers (Plants) and consumers (animals) for their food and release to the environment the simple inorganic and organic substances produced as by-products of their metabolisms.

The decomposers are essential for the long-term survival of a community.

They play the vital role of completing the matter cycle.

Without them the conversion does not takes place and the producers will not get the nutrient (N, P, K) required for their growth.

Therefore they are known as Saprotrophs. (Sapros = rotten, trophos = feeder).

Some Detrivores (e.g., : ants, earthworms, millipedes, crayfish, crabs etc.) are also helping the decomposers in releasing the essential elements in the Environment.

Productivity and Decomposition

Primary Productivity:

- It is define as the rate at which producer absorbs radiant energy from sun and convert in to organic matter by action of photosynthesis.
- Out of total produced organic matter some of the organic matter get oxidized and burnt inside the body of producer for their routine activity.
- Finally, it is converted to CO_2 which in turn released from the body by process of respiration. Thus, it is considered as a loss of energy from body of producer.
- Thus producer is left with some less organic matter than it has produced and it is called Net Primary Production (NPP)
- Thus initial production of organic matter is called Total Primary Production (TPP).
- So, NPP = TPP – Energy losses

Secondary Production:

- The rate of increase in the biomass of consumers per unit area and time is called secondary productivity.
- It is the energy stored at any trophic level for use which is used by next trophic level which in general defined as a secondary production.

Food Chains

It is just a sequence of organisms, in which each is food for the next.

All organisms dead or alive, are potential sources of food for another.

Energy and essential materials are transferred from creature to creature through food chains.

Thus, the transfer of food energy from the source in plants through a series of organisms with repeated stages of eating and being eaten up is known as the food chain.

Most food chains have no more than four or five links. There cannot be too many links in a single food chain because the animals at the end of the chain would not get enough food (and hence energy) to stay alive.

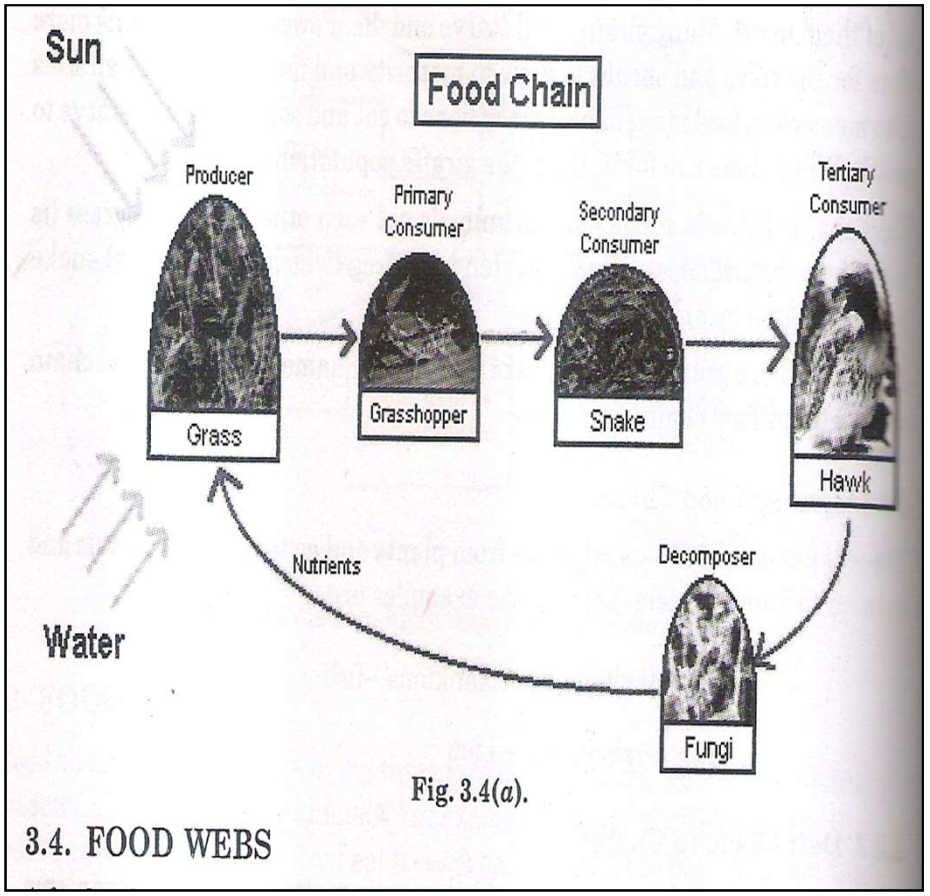


Fig. 3.4(*a*).

3.4. FOOD WEBS

Food Chains

Food chains:

During the process of eating and being eaten up, energy is passed from one organism to another.

E.g. :

- In Forest ecosystem energy is fixed by photosynthesis in tree leaf.
- Some of the energy is used immediately by the leaf to keep its own activities going. Unused energy is stored in roots, stems, flowers, and fruits. A part of its lost in the transfer and is used to make other organic compounds like Protein etc.
- Caterpillars feed on leaves. Some of the energy they gain, is used during digestion while some is stored as fat for future growth and movement.
- A Carnivores like a bird that feeds upon grasshoppers and caterpillars uses some of the energy in searching food and part of the energy is used to maintain its own metabolic processes.
- When the bird dies, the remaining energy is used by decomposers.
- In forest, dead leaves and twigs are chewed by many animals such as earthworms and termites, each takes some energy from the dead material.
- Woody tissues, hair and feathers are digested by certain bacteria and fungi.

Food Chains

They are of two types:

- **Grazing Food Chain**:
  - It starts from green plants and ends with carnivores passing through herbivores i.e. grazing animals
  - Most of the ecosystem in nature follow this type of food chain.
  - They directly depend upon solar influx.
  - E.g.: Phytoplankton – zooplanktons – fish. Grass – rabbit – fox – lion.
- **Detritus Food Chain**:
  - These types of food chain goes from dead organic matter into microorganisms to organisms feeding on detrivores and their predators.
  - They are less dependent to solar influx.

Food Chain System:

Broadly divided into three basic categories.

- The predator chain which starts from a plant base and goes from smaller to larger animals.
- The parasitic chain that goes from larger to smaller organisms.
- The saprophytic chain that goes from dead matter to microorganisms.

Detritus Food Chain

The organic wastes, exudates, and dead matter derived from the grazing food chain are termed as detritus.

The energy contained in the detritus is consumed by detrivores that form the detritus food chain in the ecosystem.

The organisms of the detritus food chain include algae, bacteria, slime molds, actinomycetes, fungi, protozoans, insects, mites, crustaceans, rotifers, nematodes and some vertebrates.

They ingest partially decomposed organic matter, digest them partially and after extracting chemical energy for their metabolism, excrete the remainder in the form of slightly simpler organic molecules and then further into CO2 and H2O.

Finally they form humus.

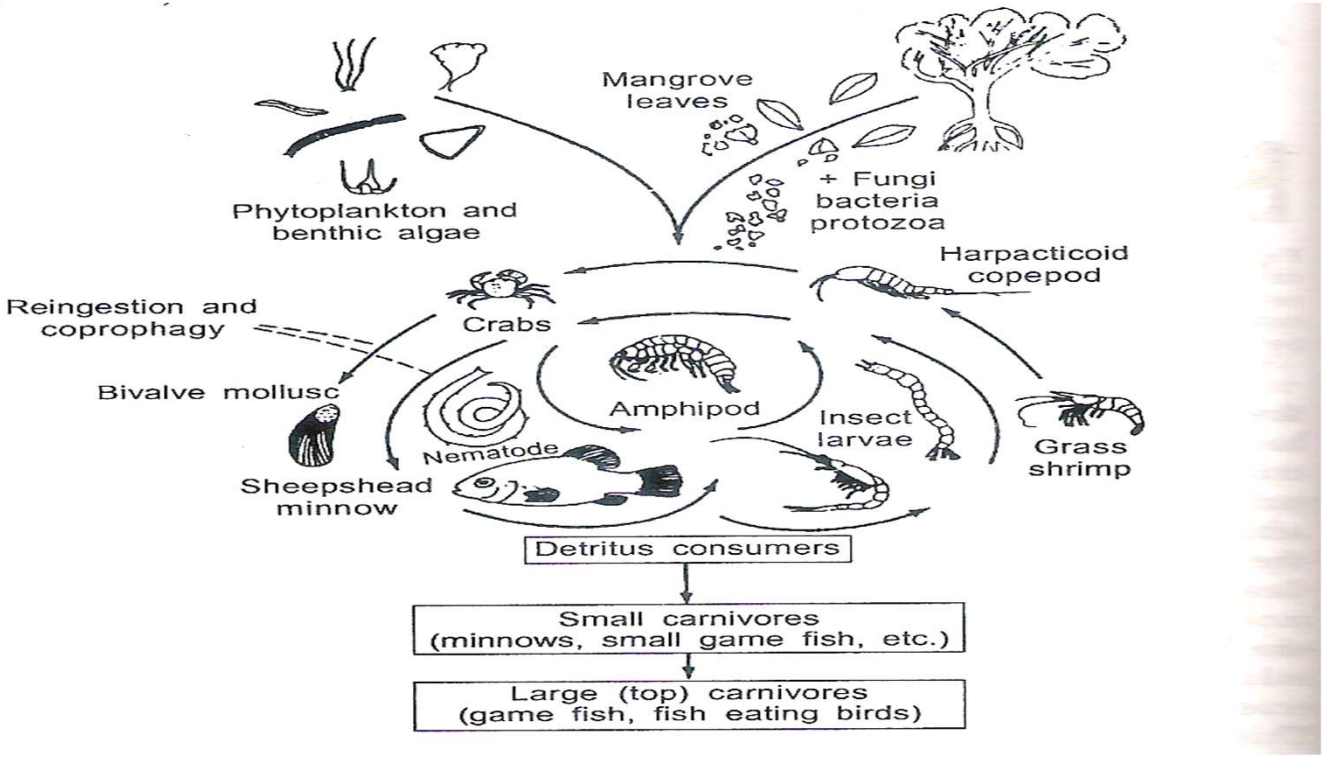
Thus these ecosystem are less dependent on direct solar energy.

Example : Mangrove leaves (Worked on the Delay Consumption System).

- A detritus food chain that begins with red mangrove leaves that fall into shallow subtropical estuarine waters. The decaying detritus particles are enriched by microorganisms and provide food for a key group of detritus consumers which in turn are food for fish.

Detritus Food Chain

A detritus food chain that begins with red mangrove leaves that fall into shallow subtropical estuarine waters. The decaying detritus particles are enriched by microorganisms and provide food for a key group of detritus consumers which in turn are food for fish.



Food Web

Simple food chains is rarely occurring in nature.

The same organism can operate at more than one trophic level.

It may be eaten up by several organisms of a higher trophic level, or several organisms may feed upon it.

Size of the food, availability of the food, and age determine this relationship.

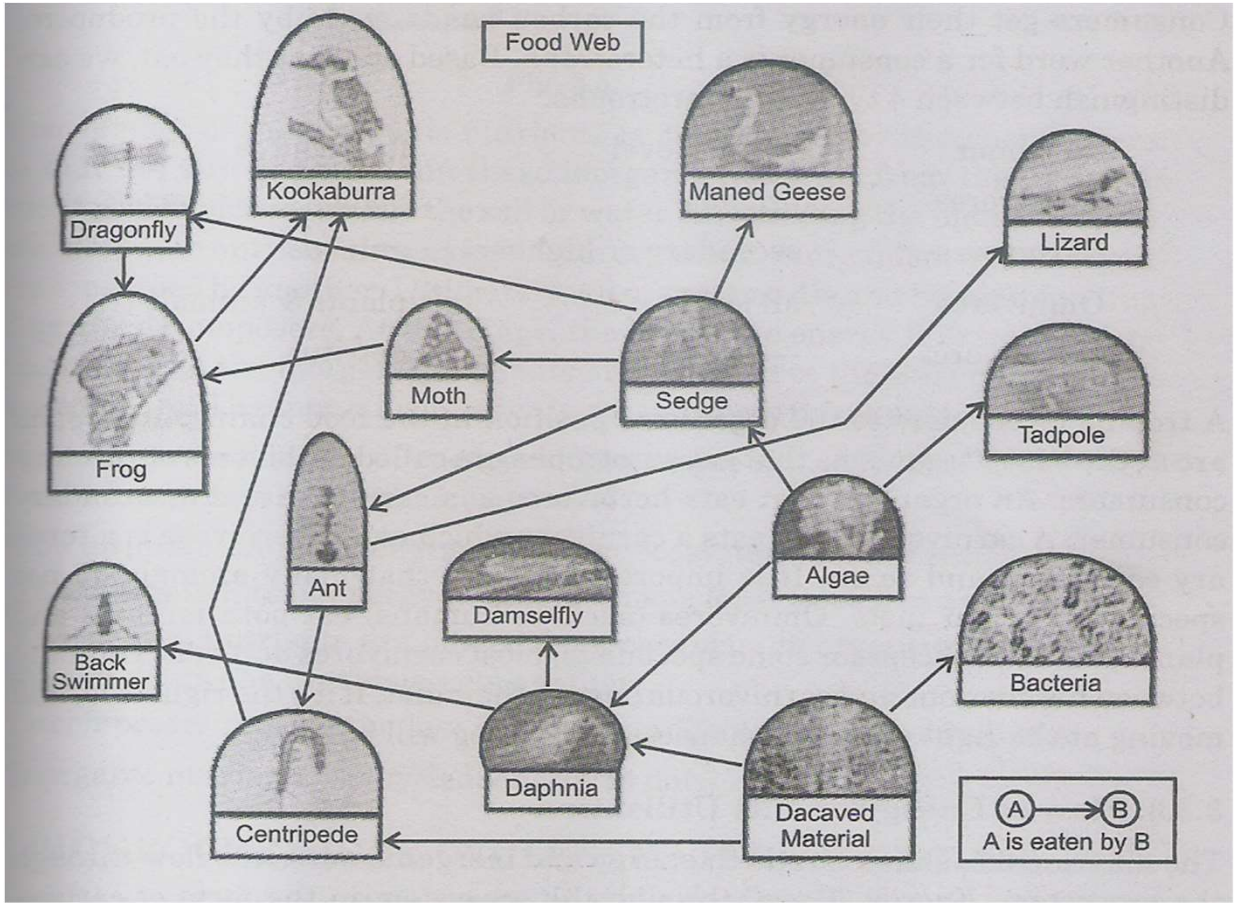
Thus, one can find that various food chains are interlinked together in the form of a food web.

Example:

- In the oceans, single celled planktonic algae make the first trophic level.
- They are eaten by small invertebrates that form the second trophic level.
- Fish live on these invertebrates that from the third trophic level.
- These small fish and crustaceans are eaten up by baleen whales and make the fourth trophic level.
- Some marine mammals like the killer whale feed on the predatory fish and make the highest trophic level.

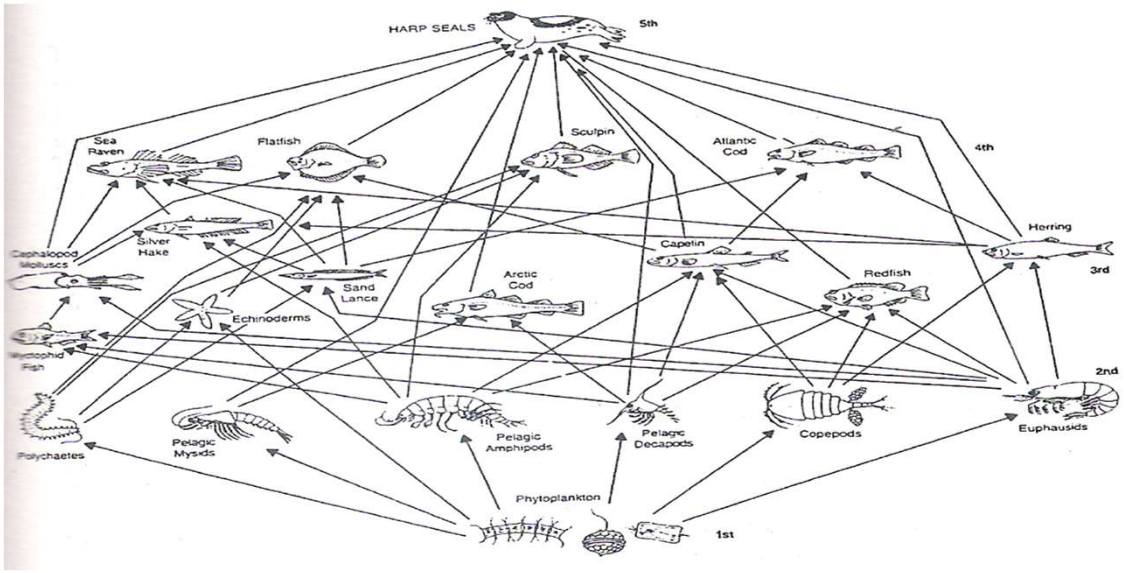
The complexity or diversity of food web has been related to the stability of ecosystem.

Food Web

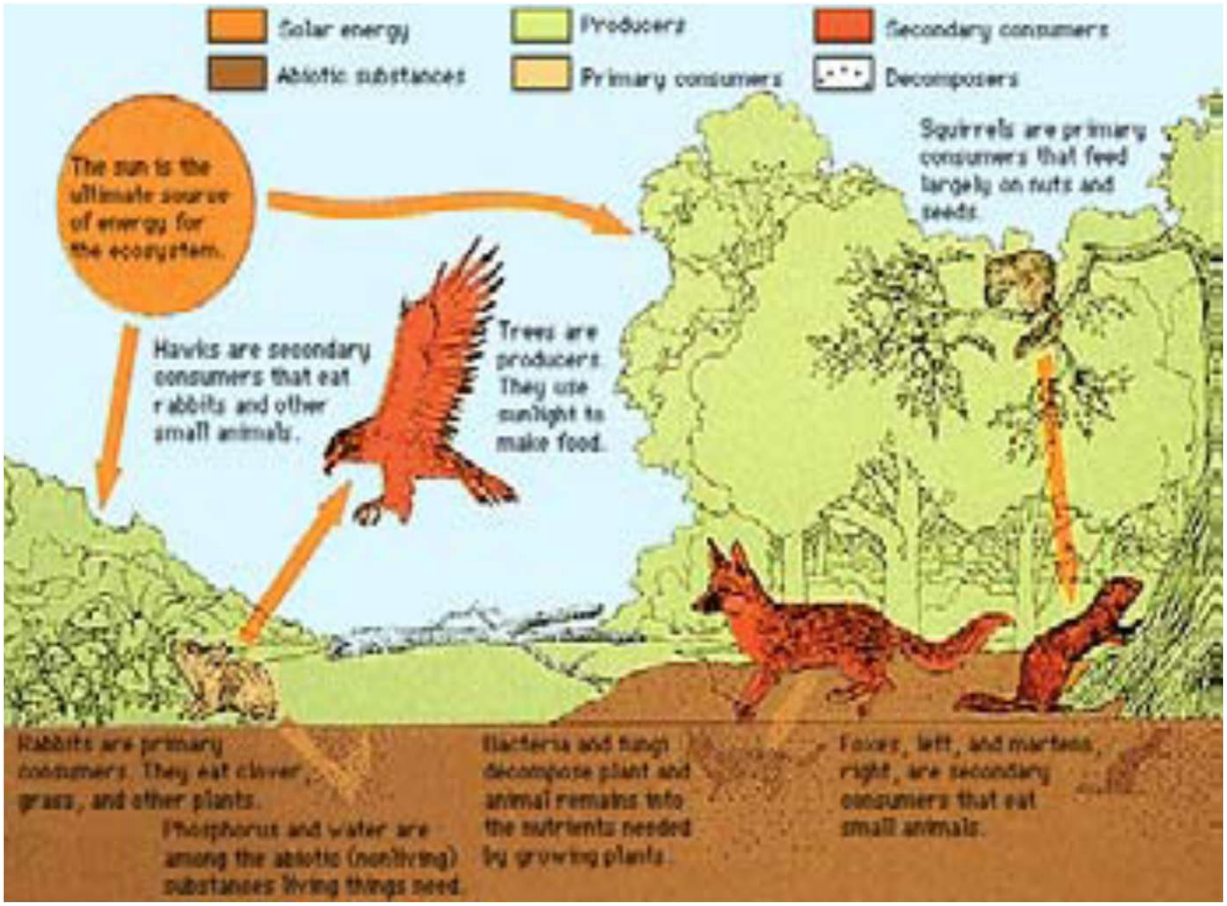

Food Web
Kookaburra
Maned Geese
Dragonfly
Lizard
Moth
Sedge
Frog
Tadpole
Ant
Algae
Damselfly
Back Swimmer
Bacteria
Daphnia
Centripede
Dacaved Material
A
B
A is eaten by B

Food Web

The food levels of the harp seal: The actual food web of the harp seal has many connections at several trophic levels. The maximum no of steps in the food chain between the harp seal and sunlight is six , but the harp seal also feeds on intermediate trophic levels. For example, it feeds on amphipods at the third trophic level and on capelin at the fourth level. The harp seal thus competes with its own prey (capelin) for its food (amphipods). Since the harp seal competes with other species, including other marine mammals and human beings, the entire food chain is very complex.



Food Web


Solar energy
Abiotic substances
Producers
Primary consumers
Secondary consumers
Decomposers
The sun is the ultimate source of energy for the ecosystem.
Squirrels are primary consumers that feed largely on nuts and seeds.
Hawks are secondary consumers that eat rabbits and other small animals.
Trees are producers. They use sunlight to make food.
Rabbits are primary consumers. They eat clover, grass, and other plants.
Phosphorus and water are among the abiotic (nonliving) substances living things need.
Bacteria and fungi decompose plant and animal remains into the nutrients needed by growing plants.
Foxes, left, and martens, right, are secondary consumers that eat small animals.

Food & Energy

Food gives energy to the organism to do biological work.

It helps them to grow, move, reproduce and survive.

Two fundamentals law of energy is acceptable.

- First Law of Thermodynamic:
  - Energy can neither be created, nor destroyed.
  - It can only be transformed from one form to another.
  - E.g. Light is a form of energy that can be transformed into heat, work or potential energy or food but it cannot be destroyed.
  - E.g.: Petrol burns in car. Chemical --- Mechanical.
- Second Law of Thermodynamic:
  - It states that whenever we transform energy from one form into another, we will lose a part of it as heat.
  - It states that all the energy, is not available to do work somewhere some loss occurs.
  - There is never any change in the total amount of energy in the universe.
  - What decrease actually is the amount of energy available to perform useful work.

Billions of years all the energy may only be in unusable form.

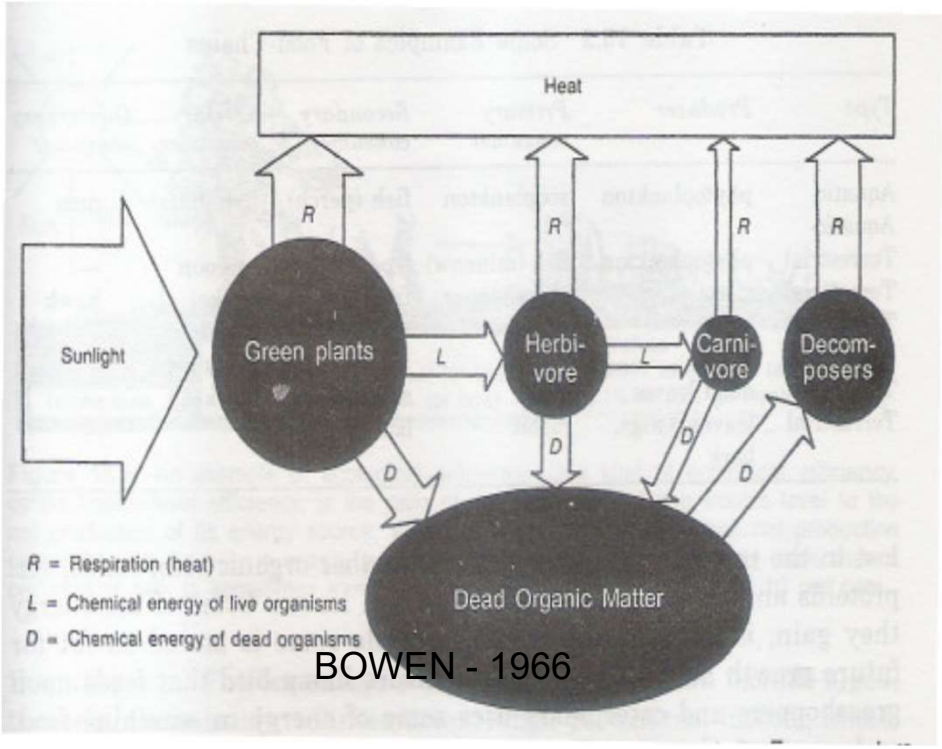
Everything will be at the same temperature, no work will be possible, and the universe will not be able to function

Energy Flow in the Ecosystem

It is the movement of energy in an ecosystem through a series of organisms.

Energy enters from sunlight passes through each tropic level.

At each level some is released as heat by respiration (R), some is transferred to the next tropic level (L) and some is transferred to the decomposers through death and excrement (D).



BOWEN - 1966

TROPHIC LEVEL & ECOLOGICAL PYRAMID

- Each organisms in an ecosystem is at a specific feeding stage called trophic level.
- This concepts come from the Greek word trophos, means nourishment.
- All the organisms that obtain their food through the same no of steps are said to belong to the same trophic level.
- The no of organisms at one trophic level is higher than the next successive level. Also the amount of energy will also gradually decrease when we move from lower level to upper level.
- When this information on no of successive levels is plotted graphically, it assumes the shape of an pyramid.
- It is due because smaller animals have a higher reproductive potential than the larger animals. Also they fall prey to larger animals.
- Thus the size, amount, availability of food, structural and feeding adjustments, method of locomotion, breeding requirements and shift in population between strata and community are involved in the formation of ecological pyramids.

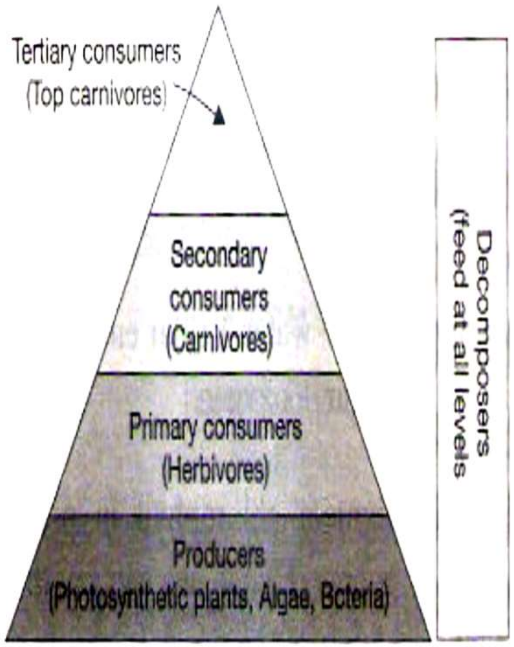


Figure 6.3 Trophic Levels

Types of Ecological Pyramid

Ecological pyramids are of three general types:

1. Pyramid of Numbers
2. Pyramid of Biomass
3. Pyramid of Energy.

The pyramids of numbers and biomass may be upright or inverted depending upon the nature of food chain, however pyramids of energy are always upright.

1. Pyramids of Numbers:

British Ecologist Charles Elton in 1927 used a proverb to explain this concept, "One hill cannot shelter two lions".

In other words a carnivore sits at the top of the food chain. There is not enough energy to support more than few carnivores.

The food chain accompanied by concomitant energy losses at each step can be visualized not only as an elegant flowing model but as a static pyramid and thereby readily conveying the image on a lone lion on the hill.

In Forest or Lake ecosystem , the pyramid is always In upright position. In Parasitic food chain the pyramid is always inverted. The no of organisms gradually increases making the pyramid inverted in shape.

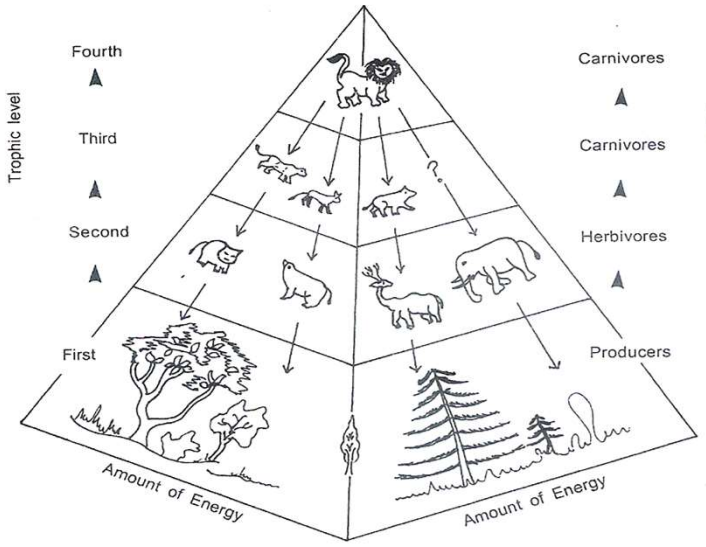
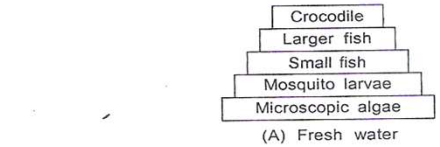
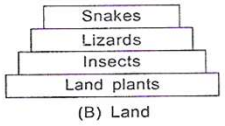


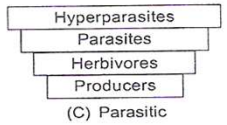
Figure 15.9 An ecological pyramid.



(A) Fresh water



(B) Land



(C) Parasitic

Types of Ecological Pyramid

2. Pyramids of Biomass:

Total dry weight, calorie value or the other suitable measurement of total living material at one time in a food chain forms a pyramid of biomass.

It is based upon the total biomass (dry matter) at each tropic level in a food chain.

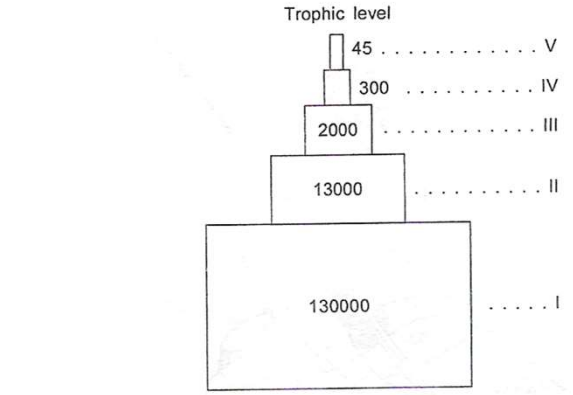
It may be upright or inverted.

In a grassland or forest ecosystem, there is gradual decrease in biomass of organisms at successive levels from producers to consumers.

These pyramids are in upright position.

In pond, producers are small organisms, so their biomass is less. But the primary and secondary consumers are bigger, so their biomass is more.

Therefore, the values of biomass show gradual increases making it an inverted pyramid like that of parasitic food chain.



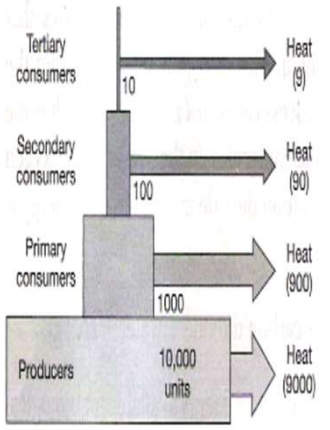


Figure 6.4 Pyramid of Energy Flow

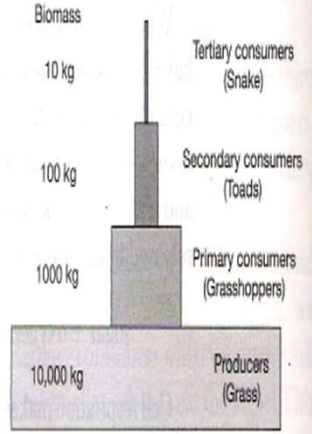


Figure 6.5 Pyramid of Biomass

Types of Ecological Pyramid

3. Pyramid of Energy:

The pyramid of energy represents the total quantity of energy utilized by different trophic level organisms of an ecosystem per unit area over a set period of time (per square meter per year).

The primary producers of an ecosystem trap the radiant energy of the sun and convert it into potential chemical energy.

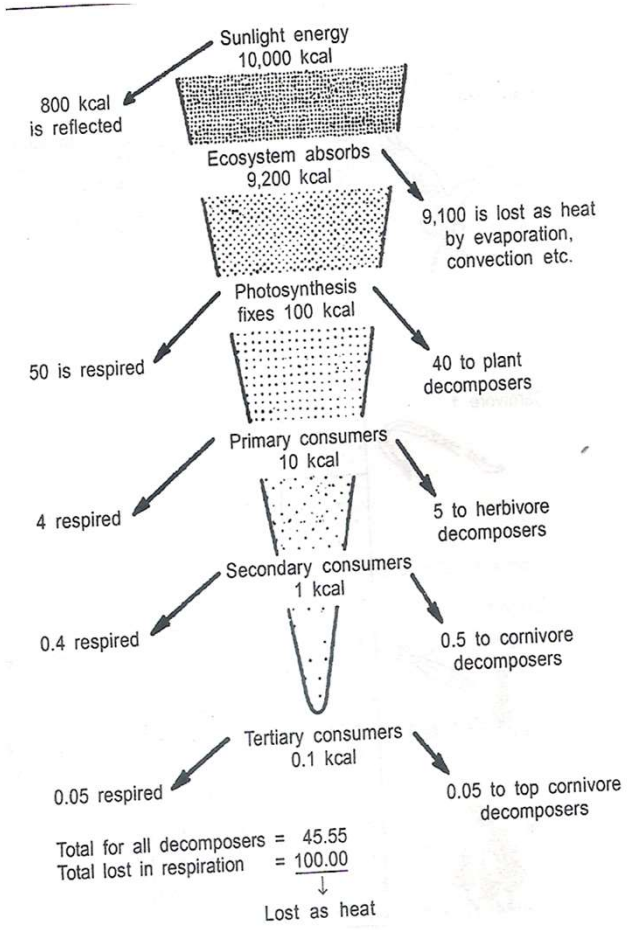
This trapped energy flows in the food chain from the producers to the top carnivores decreasing at successive trophic levels.

Pyramid of energy gives the best representation of the trophic relationships and is always upright.

At every successive trophic level, there is a huge loss of energy (about 90%) in the form of heat, respiration etc. occurs.

Thus, at each next higher level; only 10% of the energy passes on. Hence there is a sharp decline in energy level of each successive trophic level from producer to top carnivores.

It shape is always upright since in most cases there will be always gradual decrease in the energy content at each trophic levels from producers to various consumers.



Biome

A biome is a large region such as tropical rainforests, tundra, deserts (with smaller flora, fauna and microorganisms) characterized by species that are adapted to its very conditions of water, heat and soil. E.g. polar bears thrive, in the arctic while cactus plants have thick skin to help preserve water in the hot desert.

Biome is the terrestrial (land) portion of the biosphere.

Examples: Tropical rain forest, Warm-climate evergreen forests, Coniferous forests, Temperate deciduous forests, Grass lands, Hot deserts, Cold deserts, and Tundra.

Difference between Ecosystem and Biome

- An ecosystem is much smaller than a biome.
- A biome can be thought of many similar ecosystems throughout the world grouped together. I.e. Each biome may contain many ecosystem.

Biodiversity & Conservation

The word “biodiversity” is a contraction of “biological diversity”.

• The father of biodiversity Edward O. Wilson (an eminent entomologist) first coined this term in 1986.

• Diversity is a vast concept refers to the range of variations or differences among some set of entities; biological diversity thus refers to varieties within the living world.

• The term 'biodiversity' is generally considered as an ‘Umbrella term’ referring to organisms found within the living world.

• It is commonly used to describe the number, variety of life and variability of living organisms.

The variability among living organisms from all sources including, inter alia (among other things), terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Biodiversity & Conservation

The predicted number of total species varies from 5 to 50 million and averages at 14 million.

- Out of the total known species, about 60 % are insects, about 16 % are higher plants and only about 0.3 % is mammals.
- The most unique feature of Earth is the existence of life and the most extraordinary feature of life is its diversity.
- Bio-diversity is normally treated in terms of genes, species and ecosystems in correspondence with three fundamental hierarchical levels of biological organization.
- The three diversities are referred as genetic, species and ecosystem diversity.

Sometimes landscape (is a heterogeneous land area composed of cluster of interacting ecosystems that is repeated in similar form throughout or mosaic of heterogeneous land forms, vegetation types and land uses) or pattern diversity is considered as fourth forum of bio-diversity.

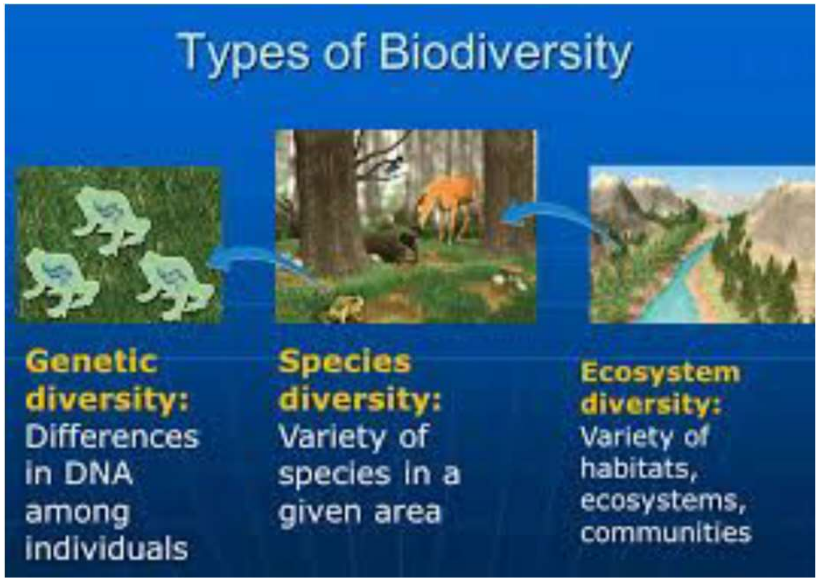
- Diversity will be:

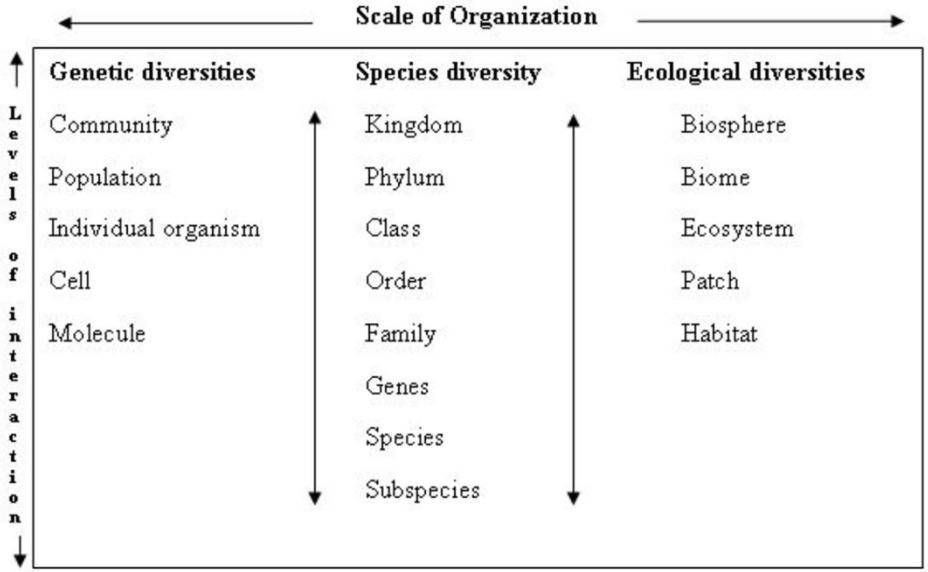
  Within the species is genetic diversity

  Between species is species diversity or taxonomic diversity or organismal diversity

  At ecological or habitat level is ecosystem or ecological diversity.

Biodiversity & Conservation





The scale of organization and level of interaction of biodiversity

Uses of Biodiversity

The different types of the direct-use value of biodiversity are for food, medicine, biological control, industrial materials, recreational harvesting and ecotourism.

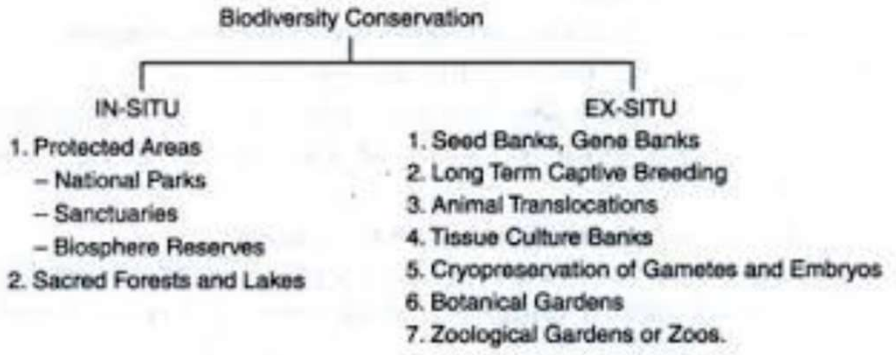
- Food: in form of vegetables, fruit, nuts, meat, milk as well as food colorants, flavoring and preservatives.
- Medicine: Willow trees (salicylic acid; aspirin), Foxglove (digitoxin), Atropa belladonna (atropine), Opium sativum (codeine), Papaver somniferum (morphine), Chinchona ledgeriana (quinine).
- Animals source products (e.g. anticoagulants, coagulants, vasodilator agents) and for models on which to test potentially useful drugs or techniques.
- Biological control: Vector Control using biological aget
- Industrial materials: building materials, fibers, dyes, resins, gums, adhesives, rubber, oils and waxes, agricultural chemicals (including pesticides) and perfumes.
- Recreational harvesting: It is the harvesting of animals (e.g. fish, reptiles, birds, mammals) for display and as pets.

There are 34 hot spots for conservation of biodiversity has been identified worldwide, including four Indian hotspots.

Conservation of Biodiversity

Conservation is defined as management of human use of biosphere so that it may yield sustainable benefit to the present generation while maintaining its potential to meet the needs and aspirations of prosperity.

- There are two basic strategies of biodiversity conservation
- In-situ (on site) and
- Ex-situ (off site).



In-situ (on site) :

- Conservation of organism in its natural home through protection of a group of typical ecosystems by a network of protected areas, biosphere reserves, sacred forests and sacred lakes.
- Protected areas: such as National Parks and Wildlife
- Sanctuaries are areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources.
- There are more than 37000 protected areas around the world, while India has 612 protected areas (99 National Parks and 513 Wildlife Sanctuaries).

Conservation of Biodiversity

Biosphere reserves: are a special category of protected areas of land and/or coastal environments, wherein people are an integral component of the system.

- A biosphere reserve consists of core, buffer and transition zones.
- The core zone comprises an undisturbed and legally protected ecosystem.
- The buffer zone surrounds the core area and is managed to accommodate a greater variety of resource use strategies, research and educational activities.

The transition zone, the outermost part of the biosphere reserve, is an area of active cooperation between reserve management and the local people,

- Wherein activities like settlements, cropping, forestry and recreation and other economic uses continue in harmony with conservation goals.
- There are 408 biosphere reserves located in different countries out of which 13 biosphere reserves located in India.

Conservation of Biodiversity

Ex-situ (off site) :

Conservation of organisms in botanical gardens, zoos, conservation stands, gene, pollen, seed, seedling, tissue culture and DNA banks.

- There are more than 1500 botanical gardens in the world containing more than 80,000 species and many of these now have seed banks, tissue culture facilities and other ex situ technologies.
- Similarly there are more than 800 professionally managed zoos around the world with about 3000 species of mammals, birds, reptiles and amphibians.
- Many of these zoos have well developed captive breeding programmes.
- Plants and animals conserved in botanical gardens, arboreta, zoos and aquaria can be used to restore degraded land, reintroduce species into wild, and restock depleted populations.

Conservation of Biodiversity

India is known for its rich heritage of biodiversity

• It is one of the 17 mega-diverse countries in the world with 7–8 % of the world's recorded plant and animal species.

• Amongst the existing biota, 91,307 species of animals (2,557 Protista), 12,470 general invertebrates, 69,903 arthropods, 4,994 vertebrates, and 45,500 species of plants as well as 5,650 microbial species have been documented in India.

• About 5,150 plant species and 1,837 animal species are endemic to India.

• Its cultural and traditional diversity includes over 550 tribal communities of 227 traditional groups spread over 5,000 forested villages.

Biogeochemical cycles

Earth is a closed system for matter.

All the elements needed for life to exist on the planet were present in the earth's crust since earth's formation (billions of years ago).

This element (C, H, O, N, S, K, P etc.) which are the building blocks of life continually cycle through the atmosphere, hydrosphere, biosphere, and lithosphere.

They forms complex organic molecule further consumed and then decomposed and released back into the environment.

Thus nutrients require for the growth of living and reproducing are continuously taken from the abiotic environment----consumed----recycled back to the environment. This cycle is known as "BIOGEOCHEMICAL CYCLE".

Some elements complete a cycle in a few days, while some take millions of years.

Eg. An average water molecule remains in atmosphere for about ten days, it transported to a long distance before it falls back on earth as a rain. While some carbon atom in deep ocean sediments may take hundreds to millions of years to cycle completely through the system.

Water Cycle

- Water is not locked permanently it concurrently move constantly through various pathways in the atmosphere, biosphere and lithosphere which explains the hydrological cycle.
- More than 97% of the water on the earth is found in ocean, but remaining 3% is found on the continents and in the atmosphere (out of which 70% is locked in the glaciers and icecaps).
- Solar energy evaporates water from the earth's surface into the atmosphere. Some of this water returns to the Earth as rain or snow, passes through the living organisms, flows into bodies and further evaporate again.
- One can explain this transformation as,
  - **Evaporation and Transpiration.**
  - **Condensation and Formation of clouds.**
  - **Precipitation.**
  - **Runoff.**
  - **Infiltration.**

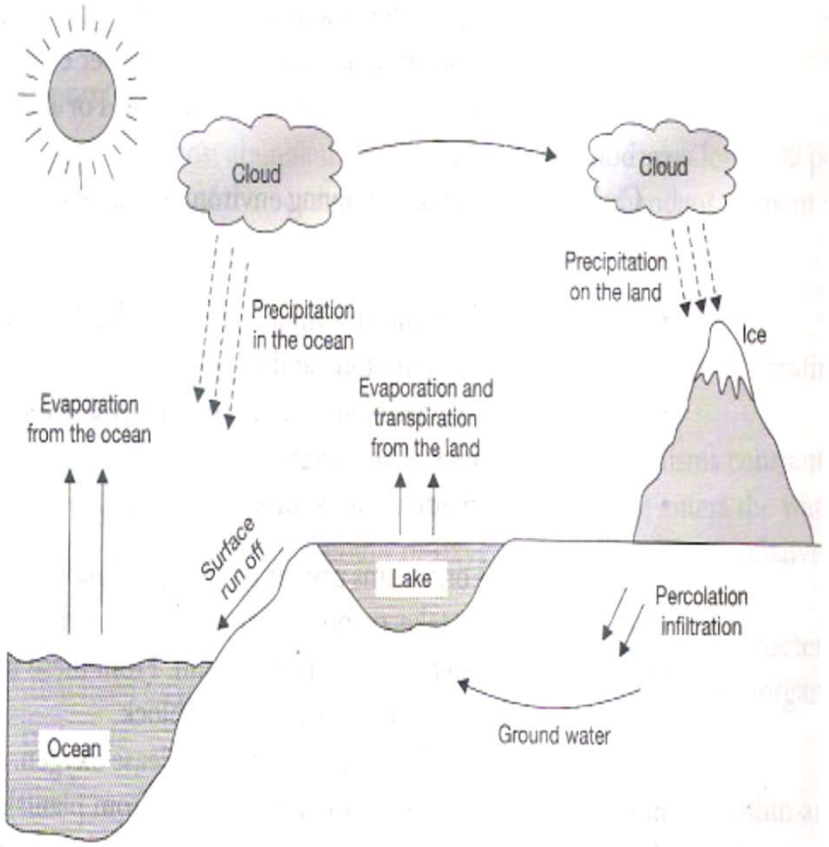


Figure 7.1 The Water Cycle

Carbon Cycle

- Carbon is the building block of all the organic substances.
- It is the fourth most imp, abundant element in the universe after H, He, O.
- Conc. of it in living matter is about 18% which is almost 100 times greater than its conc. in the earth (0.19%). Living thing gets C from the environment, so it is to be recycled.
- It exists as CO_2 in atmosphere and dissolved in water, Carbonate rocks (limestone and coral), deposits of coal, petroleum, and natural gas derived from organism, organic matter in the form of humus in the soil.
- Major sources which recycle the Carbon are:
  - Respiration of plants and animals.
  - Combustion of Fossil fuel such as coal, oil and gas.
  - Decomposition of dead organic matter of plants and animals.
  - Interchange of CO_2 between atmosphere and ocean.
  - Co_2 is one of the compound responsible for the Green House Effect.

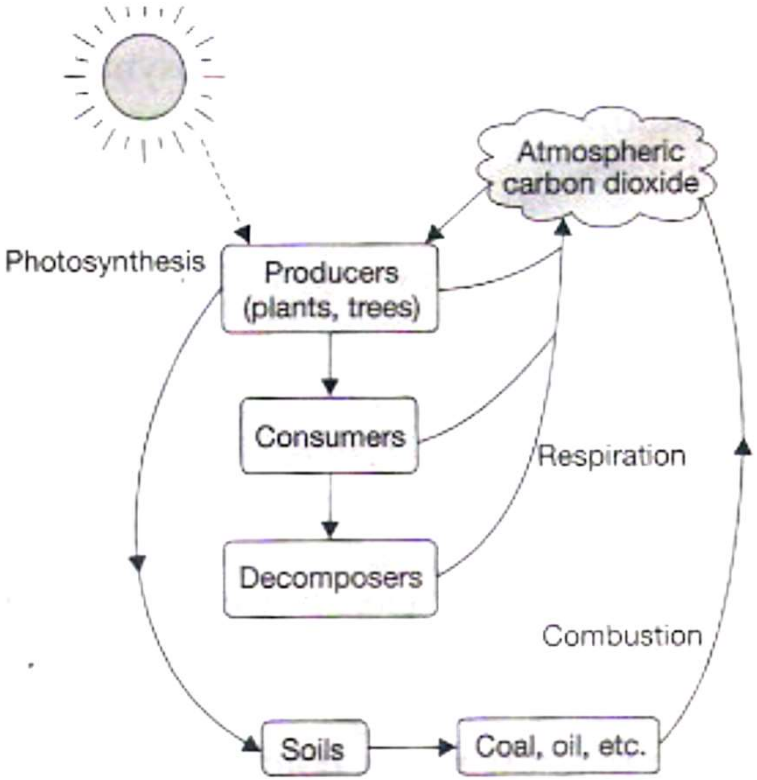


Figure 7.2 The Carbon Cycle

Oxygen Cycle

- It is the most abundant element in earth's crust & 2nd in the earth's atmosphere. It forms 89% of the mass of the ocean.
- Almost all living things need oxygen during the process of creating energy in living cells.
- Oxygen dissolved in water supports aquatic life. The decomposition of organic waste also requires oxygen.
- Thus, oxygen cycle is the movement of oxygen within and between its three main reservoirs, that is, the earth's crust, atmosphere and living organisms.
- Oxygen is absorbed from the environment during aerobic respiration, which is further been used by the animals to breakdown the carbohydrates to get the energy.
- Plants must break carbohydrates into energy just as animals do . During the day, plants hold a bit of oxygen produced during photosynthesis, but majority is released by it during photosynthesis thereby setting up the oxygen cycle. In night the case is reverse.
- There is a continuous exchange of O_2 between the atmospheric and all water surfaces on the earth. The total amount of O_2 in the biosphere is relatively constant so, That the oxygen cycle may get stable.
- Marine animals also take part in the cycle by preparing $CaCO_3$ which deposits in the earth crust consumed by animals in form of nutrients & released back once again into the environment.

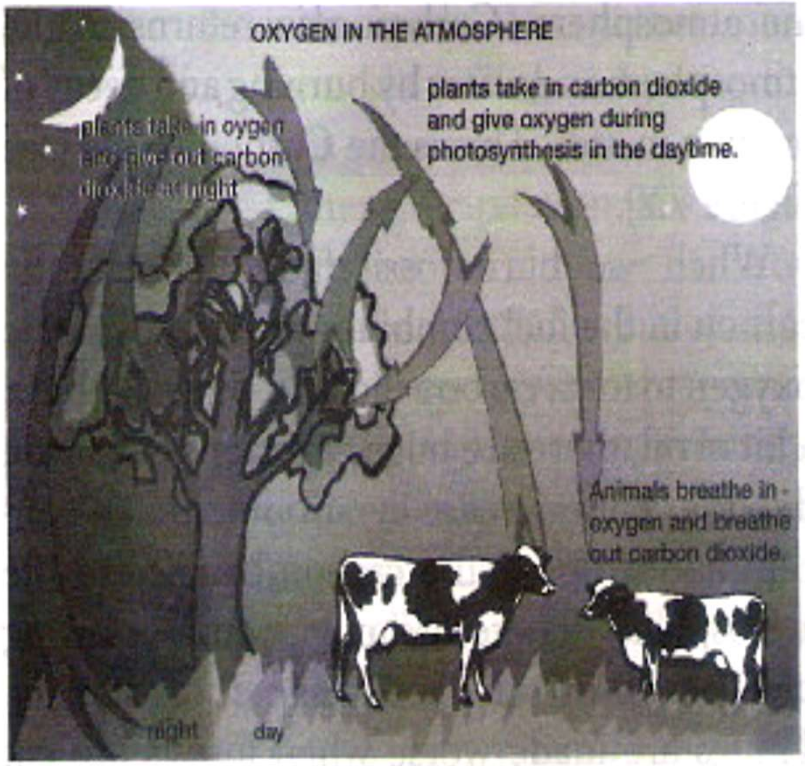


Figure 7.3 The Oxygen Cycle

Nitrogen Cycle

- To make protein and nucleic acid every animals and plants requires Nitrogen. It cannot be directly used but be fixed and combined with other elements like C,H,O.
- By fixation nitrogen is converted into its chemical compounds, largely nitrates (NO_3) and ammonia (NH_4^+) and urea. In gaseous form it constitutes 79% of the atmosphere.
- The nitrogen cycle involves the following four processes in which microorganisms play major roles: **Nitrogen fixation, Decay, Nitrification, Denitrification.**
- The first three processes 'Fix' nitrogen from the atmosphere and move it through ecosystems. Denitrification reduces nitrates to nitrogen gas, thus replenishing the atmosphere.
- The nitrates are assimilated to from acids, urea and other organic residue in the producers, consumers and decomposers cycles.
- Many legumes , in addition to fixing atmospheric nitrogen also perform nitrification-converting some of their organic nitrogen to nitrites and nitrates.

Organic Nitrogen (Protein, Amino acids) **Ammonification** → NH_3

Nitrification process

NH_3 → Nitrite forming bacteria → NO_2 (Nitrosomonas)

NO_2 → Nitrate forming bacteria → NO_3 (Nitobacter)

Denitrification process

NO_3 → Denitrifying bacteria → N_2 / NO_2/NH_3

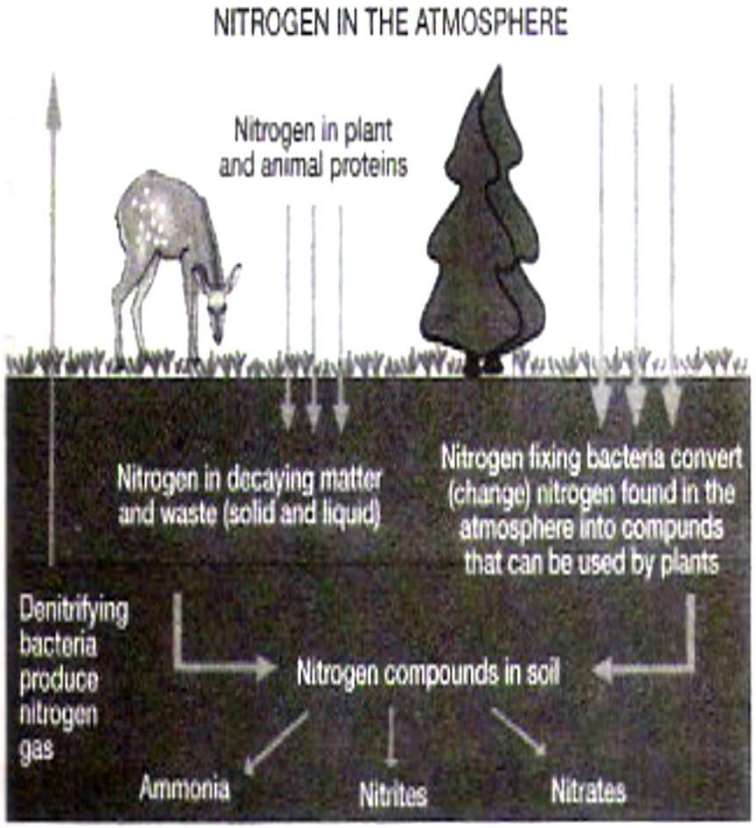


Figure 7.4 The Nitrogen Cycle

Sulphur Cycle

- To make protein and vitamins every animals and plants requires Sulphur. Plants absorbs Sulphur when it is dissolved in water.
- In environment Sulphur is found as Sulfides and Sulphates and in organic form. Most of the earth's Sulphur or sulfates is stored underground in rocks and minerals or in deep ocean in oceanic sediments.
- It enters the atmosphere from,
- **Natural Sources**: Volcanic eruptions: SO_2, H_2S, Anaerobic decomposition of organic matter in swamps and tidal flats, Particle of sulfate salts such as $(NH_4)_2SO_4$ from sea spray, dust storm and forest fire, Sediments in form of FeS_2.
- **Through Human activities:** Industrial processes emits gases such as SO_2 &H_2S.
- SO_2 enters the atmosphere, it reacts with oxygen to produce SO_3 gas or Sulphur salts. It also reacts with water to produce sulphuric acid.
- Sulphuric acid may also be produced from dimethylsulphide, which is emitted in atmosphere by plankton species.
- **Desulfovibrio** bacteria found largely in ocean bottom **Thiobacillus, Chlorobactriaceae** and **Thiorhodaceae** also plays major role in converting different form of sulfur into elemental sulfur.
- This will again mixes with snow and rain water and come back to earth which completes the cycle of ecosystem.

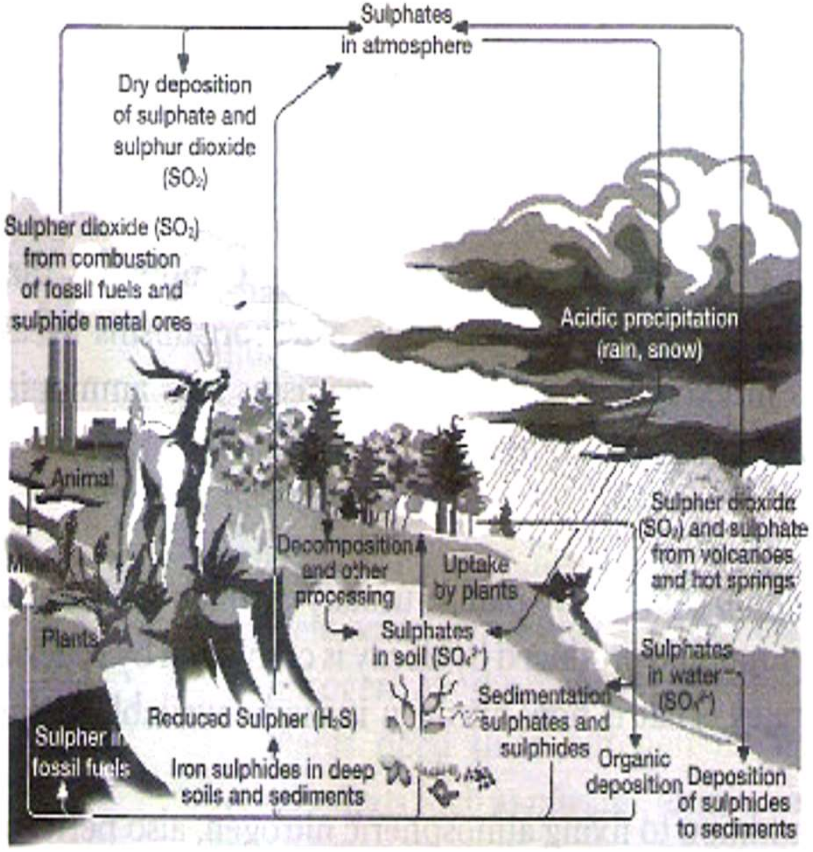


Figure 7.5 The Sulphur Cycle