PRE-MEDICAL

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STUDY MATERIAL

Organism and Environment (Ecology)

ENGLISH MEDIUM

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RAMDEO MISRA (1908-1998)

Ramdeo Misra is revered as the Father of Ecology in India. Born on 26 August 1908, Ramdeo Misra obtained Ph.D in Ecology (1937) under Prof. W. H. Pearsall, FRS, from Leeds University in UK. He established teaching and research in ecology at the Department of Botany of the Banaras Hindu University, Varanasi. His research laid the foundations for understanding of tropical communities and their succession, environmental responses of plant populations and productivity and nutrient cycling in tropical forest and grassland ecosystems. Misra formulated the first postgraduate course in ecology in India. Over 50 scholars obtained Ph. D degree under his supervision and moved on to other universities and research institutes to initiate ecology teaching and research across the country.

He was honoured with the Fellowships of the Indian National Science Academy and World Academy of Arts and Science, and the prestigious Sanjay Gandhi Award in Environment and Ecology. Due to his efforts.

- The Government of India established the National Committee for Environmental Planning and Coordination (1972).
- In later years, paved the way for the establishment of the Ministry of Environment and Forests (1984).

ORGANISM AND ENVIRONMENT (ECOLOGY)

01. INTRODUCTION

- **Introduction**
- **Ecological Hierarchy**
- **Environmental Issues (Pollution)**
- **Biodiversity and conservation**
- **Demography**

- The term ecology was coined and described by **–E.Haeckel**
- Father of ecology **– Reiter**
- Father of Indian Ecology **– Prof. Ram Deo Mishra**
- First of all term ecology was employed for study of plant by **– Warming**

The study of interaction or inter-relationship of organisms with their environment is called ecology.

Organism $\rightleftharpoons$ Environment

Organism and environment are always interdependent, inter-related or mutually reactive.

Ecology is a subject which studies the interactions among organisms and between the organism and its physical (abiotic) environment.

- **Branches of Ecology –** It is based on organisation level.

(a) **Autecology –** Study of the relation of a single species with its environment is known as autecology (Here unit of study is a single species). It is also called species ecology.

(b) **Synecology –** Study of the relation of the group of different species with their environment is known as synecology. (Here unit of study is community.)

02. ECOLOGICAL HIERARCHY

Organism $\rightarrow$ Population $\rightarrow$ Community $\rightarrow$ Ecosystem $\rightarrow$ Biome $\rightarrow$ Biosphere

$\longrightarrow$

Size $\rightarrow$ Increase
Complexity $\rightarrow$ Increase

Note :

- Ecology is basically concerned with four levels of biological organisation – organisms, populations, communities, biomes.
- **Landscape :**

  It is a unit of land with a natural boundary having a mosaic of patches. These patches generally represent different ecosystem.

  In ecological hierarchy landscape can be present between Ecosystem and Biomes.

- **Habitat :**

  Physical area where an organism lives. The physico-chemical (abiotic) components (mainly temperature, water, light and soil) alone do not characterise the habitat of an organism completely; the habitat includes biotic components also – pathogens, parasites, predators and competitors – of the organism with which they interact constantly.

- **Micro climate and Micro habitat :**

  Subdivision of habitat is called microhabitat. Microclimate is an immediate climate (real climate) of an organism which is different from the average climate of region. **e.g.** Forest floor, Burrow and surface of desert.

(1) ORGANISM

An organism is the smallest unit of ecological hierarchy and basic unit of ecological study.

- It may be small/large, unicellular/multicellular.
- Fixed life span (birth to natural death) and organized life cycle.
- Ecology at the organismic level is essentially physiological ecology, which tries to understand how different organisms are adapted to their environments in terms of not only survival but also reproduction.

(2) POPULATION

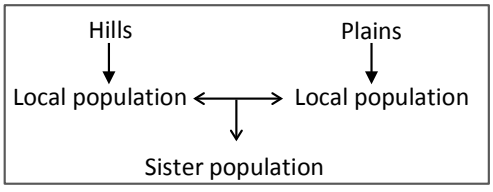
A group of Individuals (members) of same species living at one place (specific geographical area) constitute a population.

(A) Local Population or demes (Sub groups of population) :-

Population of organism inhabiting a particular area. **eg.** *Homo sapiens* inhabiting hills, plains

(B) Sister population :-

Different population of same species of organisms which are found in different places are known as sister population.



(C) Metapopulation :-

A set of local population which are interconnected by dispersing individuals.

SPECIES

Definition - Species is a basic unit of classification, defined as the group of living organisms similar in structure,function and behaviour and produced by similar parents, have common gene pool, can inter breed under natural conditions and reproductively isolated from other group of organism.

Some terms related to species :

- **Endemic Species or Endemism :**
  A species which is found only in a particular area is known as endemic species.
  e.g. *Metasequoia* is found only in valley of China, Kangaroo in Australia
- **Key-stone Species :** The species which have great influence on the community's characteristics relative to their low abundance or biomass are called key-stone species. The activities of key-stone species determine the structure of the community.
  e.g. Lion in forest, Kangaroo rat in desert, Fig tree in tropical forest.
- **Critical Link Species :** The species which establishes an essential link with other species to help the latter in some vital activity is called critical link species.
  e.g. Mycorrhizal fungi, many insect species which works as pollinators of flowers.

(3) COMMUNITY

Groups of organisms of different species that live in common area, which are interrelated and interdependent. It is a natural aggregation of plants, animals and microbes (biotic community) interacting in the same environment/area.

Biotic Community = Animal community + Plant community + Microbial community

(A) Characteristics of a community :-

(i) Species Diversity :-

There are different types of population (species) found in community, this is called species diversity. It depends on size of the area, type of area, type of soil, altitude, climate.

(ii) Dominance :-

The highest number of organism of a species present in community, is called as the dominant species. Whole community is known by the name of that particular dominant species. **e.g.** *Prosopis* in Aravali hills, *Pinus* in Himalaya

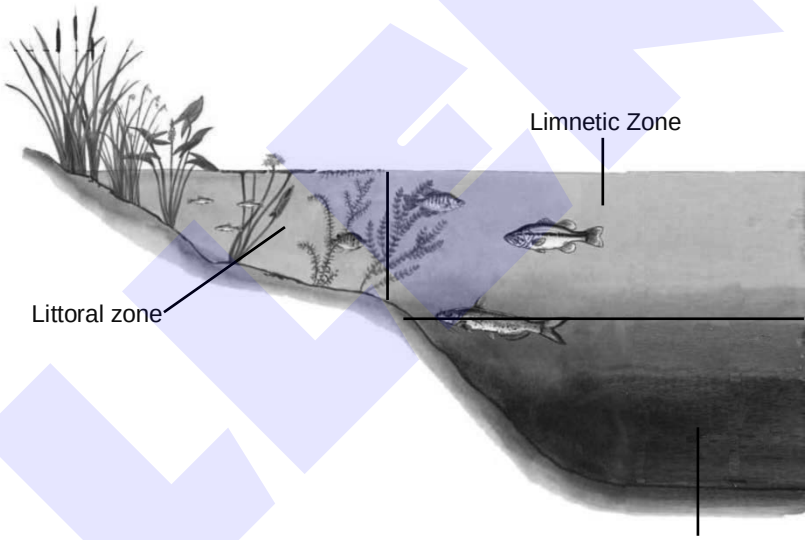
(iii) Stratification :-

The different growth forms (trees, shrubs, under shrubs, herbs) determines the structure of a plant community. Stratification is based on mode of arrangement of various growth forms.

(a) Stratification in lake :-

In deep lake, zonation or stratification may be according to the **need of light**. There are three types of zones differentiated in a deep lake.

- **Littoral Zone –** This zone is found at bank of lake where very shallow water or marshy land is present. Rooted vegetation is found in this zone.
- **Limnetic zone –** This is the zone of lake water, where light reaches in sufficient amount to entire surface area. It means this is not too deep. In this region different types of floating plants (Phytoplanktons), suspended and submerged plants are present.
- **Profundal zone –** It is very deep area of the lake where light does not reach up to the bottom. Mainly heterotrophs are present in this zone.



Stratification in lake community

Note :

Ecotone – The transition zone in between two communities is called ecotone or tension zone. It has greater number of species & density or it is a transition zone between two communities where one type of community is modifying into another type of community is known as ecotone.

Edge effect – Species which occur most abundantly and spend their time in ecotone are called edge species. The tendency to increase variety and density of some organism at the community border is known as edge effect.

(b) Stratification in forest :-

The clear stratification (vertical arrangement) in various growth forms of plants according to the need of light in any dense forest.

Surface dewellers → Herbs → Under shrubs → Shrubs → Trees

Note :

The **clear stratification** is found in tropical rain forest. So it is known as **multistoried forest.**

(B) Ecological Succession :-

Development of plant community on barren area is called ecological succession or Biotic succession. The replacement of existing community by new ones, in an orderly sequence in barren area with time due to change in environmental conditions. **Biotic communities are never stable**. They are changing more or less over period and space, due to presence of different types of climatic & environmental conditions. So a continuous interaction is going on between the community and environment till state of stability.

The gradual and fairly predictable change in the species composition of a given area is called ecological succession.

(i) Term for community in succession :-

(a) Pioneer community – The first community to inhabit an area is called Pioneer community.

(b) Climax community – The last and stable community in an area is called climax community. This is more stable. Usually **mesophytes** are present in climax community.

An important characteristic of all communities is that composition and structure constantly change in response to the changing environmental conditions. This change is orderly and sequential, parallel with the changes in the physical environment. These changes lead finally to a community that is in near equilibrium with the environment and that is called a **climax community**.

(c) Seral communities or seral stage – In succession, individual communities or stages which come in between pioneer community and climax community is called transitional or seral communities.

(d) Sere – The entire sequence of communities that successively change in a given area is called sere.

The name of sere depends on where the succession occurs or takes place.

● Succession in water	→	**Hydrosere / Hydrarch**
● Succession in salty water	→	**Halosere**
● Succession in acidic water	→	**Oxalosere**
● Succession at dry region	→	**Xerosere / Xerarch**
● Succession on rocks	→	**Lithosere**
● Succession on sand	→	**Psammosere**

(ii) Ecological succession shows certain characteristics :-

(a) Gradual replacement → from short lived to long lived plant.

(b) Continuous change occur in communities towards a state of stability or climax.

(c) Increases species-diversity, biomass, niche specialization, humus content.

(d) Future seral communities can be predicted as it is a directional process.

(e) Succession and evolution would have been parallel process.

(f) Description of ecological succession usually focuses on changes in vegetation. However, these vegetational changes in turn affect food and shelter for various types of animals. Thus, as succession proceeds, the numbers and types of animals and decomposers also change.

(iii) Causes of Succession :-

(a) **Biotic factors –** The action of each seral community with it's environment makes the area less favourable for itself and more favourable for next seral community in the succession.

(b) **Physiographic factors –** These include climatic and other physical factors like soil erosion, soil deposition, landslide, volcanic lava. These all factors makes an area barren.

(iv) Types of succession :-

(a) **Primary succession –** Occurs in the barren area where no living organisms ever existed. e.g. volcanic lava (newly cooled lava), igneous rock (bare rock), sand dunes, land slide, coral reefs and newly created pond or reservoir.

Note : It requires 1000(s) of years.

(b) **Secondary succession –** This type of succession occur where vegetation was present previously but vegetation was destroyed due to natural or artificial causes i.e. fire, flood, sudden changes in climate. e.g. In abandoned farm lands, Burned or cut forest, Flooded land.

In secondary succession the species that invade depend on the condition of the soil, availability of water, the environment as also the seeds or other propagules present.

Note : This succession is comparatively more rapid, requires 50-100 years for grass land and 100-200 years for forest.

At any time during primary or secondary succession, natural or human induced disturbances (fire, deforestation, etc.), can convert a particular seral stage of succession to an earlier stage. Also such disturbances create new conditions that encourage some species and discourage or eliminate other species.

(v) **Hydrosere :-**

Stages of hydrosere or hydrarch succession in the newly formed pond or lake

(a) **Phytoplankton stage –** It is pioneer community, first coming minute autotrophic organism. These produce organic matter e.g. Soft mud diatoms, Cyanobacteria

(b) **Rooted submerged stages –** eg. *Vallisneria*

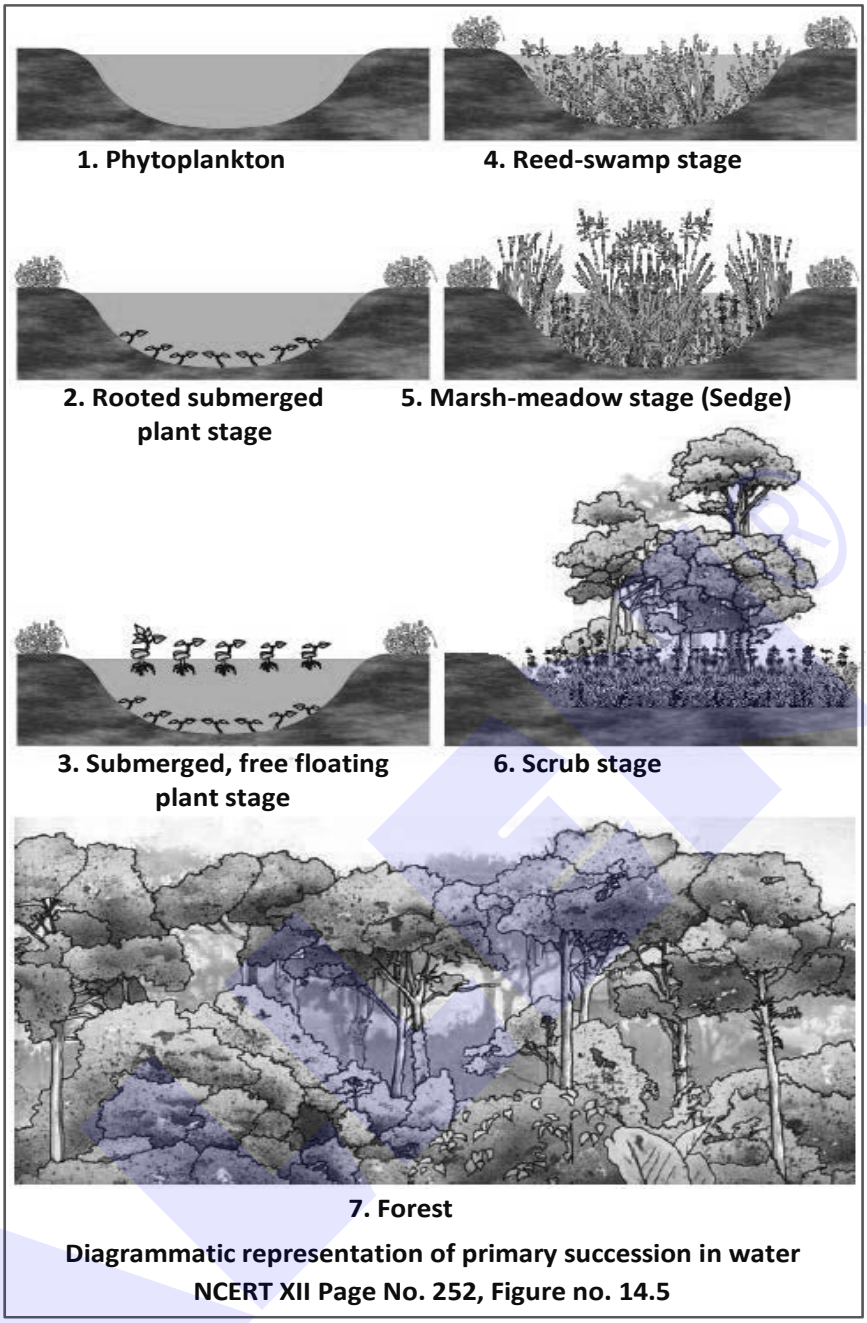
(c) **Floating stages –** Rooted floating (eg. *Nymphaea, Nelumbium),* Free floating (eg. Eichhornia, Pistia, *Azolla*)

(d) **Reed swamp stage (amphibious stage) –** Most part of these rooted plants remain exposed to air eg. *Typha*

(e) **Marsh meadow stage** (Sedge) – Muddy plants

(f) **Scrub stage –** Woody shrubs, tolerates water logging

(g) **Forest stage – e.g.** Tree (Oak, *Salix*)



Diagrammatic representation of primary succession in water
NCERT XII Page No. 252, Figure no. 14.5

(vi) **Lithosere :- Stages of Lithosere (Succession on rocks)**

(a) Crustose lichens stage – It is pioneer community, tolerates desiccation, produces organic acid which causes weathering of rocks, so first minerals are released for own use.

(b) Foliose lichens stage – large lichens with leafy thalli

(c) Moss stage

(d) Herb stage – Annual hardy grasses

(e) Shrub stage

(f) Forest stage

Note : All succession whether taking place in water or on land, proceeds to a similar climax community - the mesic.

★ Golden Key Points ★

- Ecology at the organismic level also known as Physiological ecology.
- The activities of key-stone species determine the structure of the community.
- Stratification of lake and forest found according to the need of light.
- The clear stratification is found in tropical rain forest.
- In succession, climax community is always mesophytes.
- Primary succession is slow while secondary succession is fast process.

BEGINNER'S BOX

ORGANISM, POPULATION, COMMUNITY AND SUCCESION

1. Two populations which are interconnected by dispersing individuals are known as :-

(1) Local population (2) Metapopulation

(3) Sister population (4) None

2. Kangaroo rat in desert is an example of :

(1) Keystone species (2) Critical link species

(3) Endemic species (4) Dominant species

3. *Pinus* community at Himalayas is an example of :

(1) Endemic species (2) Rare species

(3) Dominant species (4) Keystone species

4. Which of the following zone of lake stratification also known as ecotone area ?

(1) Littoral zone (2) Limnetic zone

(3) Profundal zone (4) Benthic zone

5. In which of the zone of lake stratification mainly heterotrophs are present ?

(1) Limnetic zone (2) Littoral zone

(3) Profundal zone (4) Ecotone zone

6. Succession on sand known as :

(1) Halosere (2) Hydrosere

(3) Lithosere (4) Psammosere

7. Which of the following is a pioneer community in Lithosere ?

(1) Phytoplankton (2) Foliose lichen

(3) Crustose lichen (4) Moss

(C) Inter Specific Interactions :-

Due to increase in different species in community, interaction for food, habitat and light etc. also starts between them.

(i) Positive or beneficial interaction :-

Member of one or both the interacting species are benefitted but neither is harmed.

It is a wide spread phenomenon, it includes → mutualism, commensalism, protocooperation

(a) Mutualism (+, +) or Obligate mutualism :-

co-evolution, co-existence and co-extinction

Positive inter specific interaction in which members of two different species completely depend on each other for growth and survival. **It is obligatory relationship.**

- **Mutualism between animal and animal –**

  e.g. Termites and Flagellates (*Trichonympha*)

- **Mutualism between plant & animals –**

  e.g. *Yucca* plant flowers and *Pronuba* insects – Pollination of *Yucca* plant by *Pronuba* (Female yucca moth)

- **Mutualism between photosynthesising algae or cyanobacteria and fungi –** Lichens

- **Mutualism between fungi and the roots of higher plants –** Mycorrhiza

  The fungi help the plant in the absorption of essential nutrients from the soil while the plant in turn provides the fungi with energy-yielding carbohydrates.

- **Mutualism between Fig tree and wasp species –**

  In many species of fig trees, there is a tight one to one relationship with the pollinator species of wasp, It means that a given fig species can be pollinated only by its partner wasp species and no other species. The female wasp uses the fruit not only as an oviposition (egg-laying) site but uses the developing seeds with in the fruit for nourishing its larvae. The wasp pollinates the fig inflorescence while searching for suitable egg-laying sites. In return for the favour of pollination the fig offers the wasp some of its developing seeds, as food for the developing wasp larvae.

- **Mutualism between Bees and Orchid flower –**

  Orchids show diversity of floral patterns, which have evolved to attract the right pollnator insect (bees and bumblebees) and ensure guaranteed pollination by it.

  The mediterranean orchid ***Ophrys*** employs "sexual deceit" to get pollination done by a species of bee. One petal of its flower bears resemblance to the female of the bee in size, colour and markings. The male bee is attracted to what it perceives as a female, **pseudocopulates** with the flower and during that process is dusted with pollen from the flower, it transfers pollen to it and thus, pollinates the flower.

(b) Commensalism (+, 0) –

Association between members of two different species in which one is benefitted while other is almost unaffected.

- **Lianas –** are woody vines. Their roots are present in soil but their stem use other plant or object for support to get better light. They are found in dense forest. No nutritional relationship. Lianas are the speciality of tropical rain forest.

  e.g. *Bauhinia, Tinospora*

- **Epiphytes –** Small plants grow on other plants in tropical rain forest. They utilise only the space of host plant for light & humidity

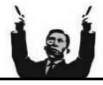
  e.g. Orchids, Hanging mosses

- **Epizones –** Those animals which depends on plants or other animals.

Sucker fish (*Echeneis*)	–	Shark
Pilot fish	–	Shark
E.coli bacteria	–	Intestine of man
Clown fish	–	Sea anemone
Barnacles	–	Whale
Cattle egret birds	–	Cattle

(c) Proto-cooperation (+/+) – Association in which both organisms are benefited but can live separately, it is a facultative or optional or occasional association also called as **non-obligatory** relationship.

- Hermit crab – Sea anemone
- Tick bird (Red-billed or yellow billed) – Rhinoceros
- Crocodile – Bird



Scavenging – Association in which one partner called scavenger or saprobiont, eats the dead bodies of other animals, which have died naturally or killed by another animal

e.g. Jackal, Vulture, Ant, Crow

Helotism – Association in between two organisms, where one behaves as a master and another as slave.

e.g. Lichen

(ii) Negative Interaction (Antagonism/Detrimental) :-

One or both interacting species is harmed.

Three type of negative interaction

(a) Exploitation

(b) Amensalism

(c) Competition

(a) Exploitation – One species harms the other by making its direct or indirect use for support, shelter or food.

It is of two types :- Parasitism & Predation

- **Parasitism (+ / –)** → This association involves individuals of two species of different size in which smaller (Parasite) is benefitted and larger (host) is harmed. The parasite gets nourishment and shelter from host but **do not kill** the host.
- Majority of the parasites harm the host; they may reduce the survival, growth and reproduction of the host and reduce its population density. They might render the host more vulnerable to predation by making it physically weak.

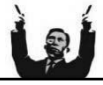
- Many parasites have evolved to be host-specific (they can parasitise only a single species of host) in such a way that both host and the parasite tend to co-evolve; that is, if the host evolves special mechanisms for rejecting or resisting the parasite, the parasite has to evolve mechanisms to counteract and neutralise them, in order to be successful with the same host species.
- In accordance with their life styles, parasites evolved special adaptations such as the loss of unnecessary sense organs, presence of adhesive organs or suckers to cling on to the host, loss of digestive system and high reproductive capacity.

Type of Parasite :

- **Ectoparasite** - lives on the body of host
  - **Ectozooparasite –** Leech on cattle, ticks on dogs, copepods on marine fish and lice on human.
  - **Ectophytoparasite –** Aphids, Lac insects, Red cotton bug live on plants.
- **Endoparasites** – live in the body of host at different sites (liver, kidney, lungs, red blood cells, etc.). The life cycles of endoparasites are more complex because of their extreme specialisation. Their morphological and anatomical features are greatly simplified while emphasising their reproductive potential.
  - Tapeworm, *Taenia, Ascaris, Entamoeba* → live in intestine of man
  - *Plasmodium* → live in R.B.C. of human.

Note : The life cycle of parasite are often complex, involving one or two intermediate host or vectors to complete their life cycle.

For example : The human liver fluke (a trematode) depends on two intermediate host (snail and fish) to complete its life cycle.



- **Hyper parasitism** → A parasite living on another parasite

  e.g. Bacteriophages on bacteria.

- **Brood parasitism** → Parasitism in which the parasitic bird (cuckoo) lays its eggs in the nest of its host (crow) and lets the host incubate them, this relation is known as brood parasitism.

- **Holo parasite**→Parasite which are totally dependent upon the host for their requirement

  e.g. *Rafflesia* (Total root parasite)

  Cuscuta (Total stem parasite) – a parasitic plant that is commonly found growing on hedge plants, has lost its chlorophyll and leaves in the course of evolution. It derives its nutrition from the host plant which it parasitises.

- **Hemiparasite** → Parasite which partially depend on the host.

  e.g. ***Viscum*** **– on oak**
  Loranthus **– on mango** } **both are partial stem parasite.**

Note :

(1) *Arceuthobium* is the smallest parasitic angiosperm.

(2) Female *Anopheles* mosquito is not considered as parasite.

- **Predation (+/–) :–** A free living organisms which catches and **kills** another species for food.
  - When we think of predator and prey, most probably it is the tiger and the deer that readily come to our mind, but a sparrow eating any seed is no less a predator.
  - Predators acting as **'conduits'** for energy transfer across trophic levels, also play other important roles. They keep prey populations under control. In the absence of predators, prey species could achieve very high population densities and cause ecosystem instability. When certain exotic species are introduced into a geographical area, they become invasive and start spreading fast because the invaded land does not have its natural predators.
  - The **prickly pear cactus** introduced into Australia in the early 1920's caused havoc by spreading rapidly into millions of hectares of rangeland (grassland). Finally, the invasive cactus was brought under control only after a cactus-feeding predator (a moth) from its natural habitat was introduced into the country.

- Predators also help in maintaining species diversity in a community, by reducing the intensity of competition among competing prey species.
- In the rocky intertidal communities of the American Pacific Coast the starfish ***Pisaster*** is an important predator. In a field experiment, when all the starfish were removed from an enclosed intertidal area, more than 10 species of invertebrates became extinct within a year, because of **interspecific competition**.
- If a predator is too efficient and **overexploits** its prey, then the prey might become extinct and following it, the predator will also become extinct due to lack of food. This is the reason why predators in nature are **'prudent'** (clever).
- Prey species have evolved various defenses to lessen the impact of predation. Some species of insects and frogs are cryptically-coloured (camouflaged) to avoid being detected easily by the predator. Some are poisonous and therefore avoided by the predators. The **Monarch butterfly** is highly distasteful to its predator (bird) because of a special chemical present in its body. This butterfly acquires this chemical during its caterpillar stage by feeding on a poisonous weed.
- For plants, **herbivores are the predators**. Nearly 25 per cent of all insects are known to be phytophagous (feeding on plant sap and other parts of plants). The problem is particularly severe for plants because, unlike animals, they cannot run away from their predators. Plants therefore have evolved an astonishing variety of morphological and chemical defences against herbivores. **Thorns (*Acacia, Cactus*)** are the most common morphological means of defence.
- Many plants **produce and store chemicals** that make the herbivore sick when they are eaten, inhibit feeding or digestion, disrupt its reproduction or even kill it. The weed ***Calotropis*** produces highly poisonous **cardiac glycosides** and that is why you never see any cattle or goats browsing on this plant.

(b) Amensalism (– / 0) –

In this interaction one species is inhibited by toxic secretion of other species.

eg. Parthenium

This interaction is widely used is medical science for production of antibiotics.

(c) Competition (–, –) : Process in which the fitness of one species is significantly lower in the presence of another species.

- It is generally believed that competition occurs when closely related species compete for the same resources that are limiting, but this is not entirely true.
- **Firstly**, totally unrelated species could also compete for the same resource. For eg. in some shallow South American lakes, visiting **flamingoes** and **resident fishes** compete for their common food, the zooplankton in the lake.
- **Secondly**, resources need not be limiting for competition to occur; in interference competition, the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species, even if resources (food and space) are abundant.
- Therefore, competition is best defined as a process in which the fitness of one species (measured in terms of its 'r' the intrinsic rate of increase) is significantly lower in the presence of another species. It is relatively easy to demonstrate in laboratory experiments, as **Gause and other experimental** ecologists did, when resources are limited the competitively superior species will eventually eliminate the other species. The **Abingdon tortoise** in Galapagos Islands became extinct within a decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.
- **Gause's 'Competitive Exclusion Principle'** states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated eventually. This may be true if resources are limiting, but not otherwise.

- More recent studies do not support such gross generalisations about competition. While they do not rule out the occurrence of interspecific competition in nature, they point out that species facing competition might evolve mechanisms that promote co-existence rather than exclusion. One such mechanism is **'resource partitioning'**. If two species compete for the same resource, they could avoid competition by choosing, different times for feeding or different foraging patterns. **MacArthur showed** that five closely related species of **warblers** living on the same tree were able to avoid competition and co-exist due to behavioural differences in their foraging activities.
- **Connell's elegant field experiments** showed that on the rocky sea coasts of Scotland, the larger and competitively **superior barnacle *Balanus*** dominates the intertidal area, and excludes the **smaller barnacle *Chathamalus*** from that zone.
- Another evidence for the occurrence of competition in nature comes from what is called **'competitive release'**. A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range when the competing species (Superior species) is experimentally removed.

Note :

- Interspecific competition is a potent force in organic evolution.
- **Ecological Niche –** Word is given by **Grinnel.** It is the **functional role** of any species in a ecosystem or community. In other words it is a **occupational address or profession** of a species it means it is a functional position or status in an ecosystem. Each organism has an invariably defined range of conditions that if can tolerate, diversity in the resources it utilises and a distinct functional role in the ecological system, all these together comprise its niche.

★ Golden Key Points ★

- Mutualism is obligatory relationship, in which related species show co-evolution, co-extinction and co-existence.
- In parasitism both host and parasite tend to co-evolve. If the host evolves special mechanism for rejecting or resisting the parasite, the parasite has to evolve mechanism to counteract and neutralise them.
- Predators help in maintaining species diversity in a community.
- In competition fitness of one species is significantly lower in the presence of another species.
- **Gause's competitive exclusion principle** states that two closely related species competing for the same resources cannot co-exist long period and the competitively inferior one will be eliminated, but this may be true if resources are limiting, but not otherwise.
- Predation, parasitism and commensalism share a common characteristic - the interacting species live closely together.
- Herbivores and plants appear to be more adversely affected by competition than carnivores.

BEGINNER'S BOX — INTER SPECIFIC INTERACTIONS

1. Relation between fig tree and wasp species :

(1) Commensalism (2) Mutualism (3) Parasitism (4) Amensalism

2. Predators help in :

(1) Maintaining species diversity

(2) Reduce the competition between prey species

(3) Maintaining ecological balance

(4) All

3. Which one is example of holoparasite ?

(1) *Cuscuta* (2) *Viscum* (3) *Loranthus* (4) Sea anemone

4. Which one is example of ectoparasite :

(1) Ticks (2) *Plasmodium* (3) *Ascaris* (4) *Taenia*

5. Relation between clown fish and sea anemone :

(1) Mutualism (2) Commensalism (3) Parasitism (4) Amensalism

(4) ECOSYSTEM

Definition – Total living factor (biotic) and total non living factor (abiotic) of the environment present in a particular area is called ecosystem.

- **A.G.Tansley –** The term "ecosystem" was coined by A.G. Tansley.

  According to Tansley – Ecosystem is symbol of structure and function of nature.
- **E.P. Odum –** Father of ecosystem ecology.

  According to E.P. Odum – Ecosystem is the smallest structural and functional unit of nature or environment.

- The boundaries of ecosystem are indistinct and have a overlapping character over each other.
- Ecosystem is the smallest structural and functional unit of nature or environment. It is a self regulatory and self sustaining unit.
- Ecosystem may be large or small. Single drop of water may be an ecosystem etc.
- Ecosystem may be temporary or permanent.
- Ecosystems are of two type - Natural or Artificial.
  - **Natural Terrestrial Ecosystem –** e.g. forest, grassland, tree, desert ecosystem etc.
  - **Natural Aquatic ecosystem –** Aquatic ecosystem is again of two type :

    Lentic ecosystem → Stagnant water e.g. lake, pond, swamp etc.

    Lotic – Running fresh water ecosystem e.g. – river, streams etc.
  - **Artificial Ecosystem /** Man made ecosystem

    e.g. cropland, gardens, an aquarium etc.
  - **On the basis of size, types of ecosystem**
    - Mega ecosystem – Ocean/Sea
    - Macroecosystem – Forest
    - Microecosystem – Pond
    - Nanoecosystem – Drop of water
- Every ecosystem is composed of two components – Biotic component & Abiotic component.
- Biotic component involve all livings (plant, animal and microbes) of ecosystem. Biotic component are mainly of two types - producer and consumer.
- Major abiotic components of ecosystems that lead to so much variation in the physical and chemical conditions of different habitats of ecosystems are temperature, water, light and soil.
- Major functional aspects of ecosystems are energy flow, nutrient cycle, decomposition and productivity.

Component and functional aspects of ecosystems :-

(A) Producers :

All the autotrophs of ecosystem are called producers. They prepare their own food. The green plants are the main producers. In the process of photosynthesis, producers absorb solar energy and convert it into chemical energy so producers are also called **transducers** or **converters.** Energy enters into the ecosystem through the producers. The **solar energy** is the only ultimate source of energy in ecosystem. This energy is available for the remaining living organisms.

In aquatic ecosystem : Floating plants called **phytoplankton** are the major autotrophs.

(B) Consumer :

All the heterotrophs of the ecosystem are known as consumers. They directly (herbivores) or indirectly (Carnivores) depend on the producers for food.

Types of consumer – Macroconsumers & Microconsumers

(i) Macro consumers (Phagotrophs or holozoic) – They digest their food inside the body i.e. first ingestion then digestion.

Macro consumers are of following type

(a) Primary consumer – Such living organisms which obtain food directly from producers or plants are known as primary consumers.
e.g. Herbivores of ecosystem, cow, grazing cattle, Rabbit etc.
These are also known as **secondary producers** .

(b) Secondary consumers or primary carnivores – Animals which feed upon primary consumers and obtain food. Those carnivores which kill and eat the herbivores.
e.g. Dog, cat, snake etc.

(c) Top Consumers – Those animals which kill other animals and eat them, but they are not killed & eaten by other animal in the nature.
e.g. Lion, man, hawk, peacock etc.

(ii) Micro Consumers/Decomposers or Saprotrophs/osmotrophs –

Those living organisms which decompose the dead body of producers and consumers are known as decomposers or reducers or transformers or osmotrophs.

Note –

- The main decomposers in ecosystem are bacteria and fungi.
- **Decomposers play a significant role in mineral cycle.** Decomposers are responsible for converting complex organic material of dead animals or plants into simpler organic matter through the process of decomposition and release mineral substances into the soil where these are reused by the producers, So that soil is considered as the best resource of minerals.

- In bacteria and fungi, process of decomposition completely takes place outside the body. They release enzymes on dead remains and decompose it into simpler organic substances and then absorb it so these are also called as **osmotrophs.**

(C) Energy flow :

The storage, expenditure, transformation of energy is based on two basic laws of thermodynamics :-

- **First Law Of Thermodynamics** (FLOT) :- Energy is neither created nor destroyed but only transformed from one state to another state.
- **Second Law Of Thermodynamics** (SLOT - the law of entropy) :- The transfer of food energy from one to another organism leads to loss of energy as heat due to metabolic activity. Further, ecosystems are not exempt from the Second Law of thermodynamics. They need a constant supply of energy to synthesise the molecules they require, to counteract the universal tendency toward increasing disorderliness.

(D) Food Chain :

In ecosystem every organism depends on other organism for food material and all organism are (Plants, herbivores, carnivores) arranged in a series in which food energy is transferred through repeated eating and being eaten. It is called food chain. In food chain, energy flow is in the form of food.

In a food chain, food material or food energy transfer is from one trophic level to next trophic level.

Generally four trophic levels are present in the ecosystem, because amount of energy decreases at successive trophic levels.

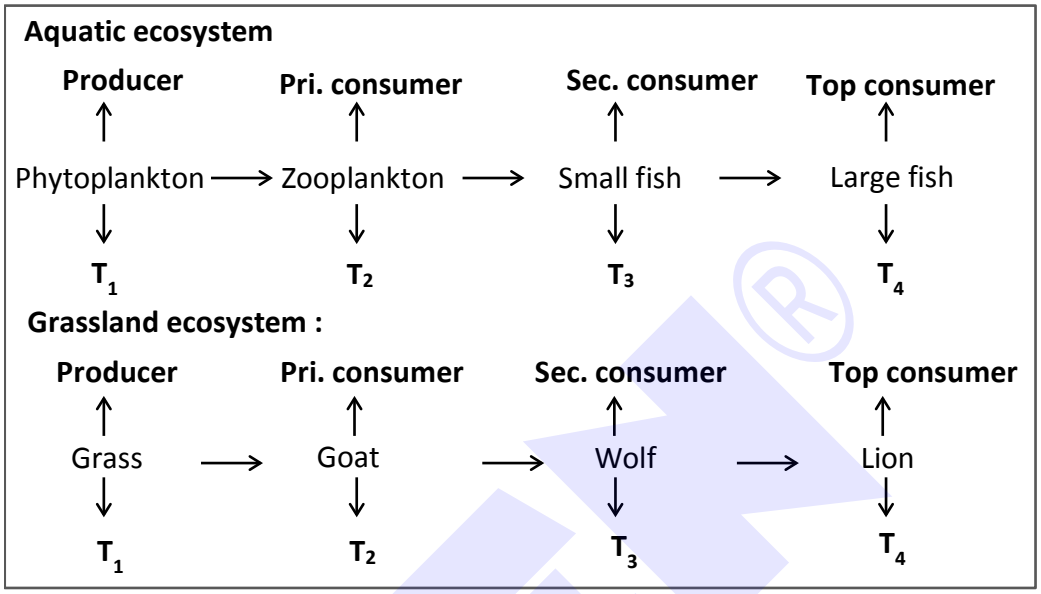
First trophic level	**$[T_1]$**	=	Producers
Second trophic level	**$[T_2]$**	=	Primary consumers
Third trophic Level	**$[T_3]$**	=	Secondary consumers
Fourth trophic level	**$[T_4]$**	=	Top consumers

Note :

- **Five trophic levels** can be present in highly complex ecosystem in which tertiary consumer is present in between the secondary consumers and top consumer. The fifth trophic level(T_5) is occupied by the top consumer.
- In food chain energy flow is **unidirectional** (producers to top consumers)
- Shorter food chains will provide greater energy.
- Generally the decomposers (Bacteria and Fungi) are not included in the food chain.

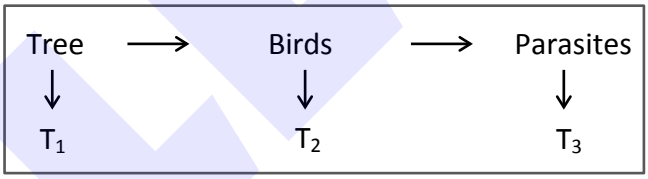
Type of food chains :- In nature three types of food chains are present

(i) **Grazing food chains or Predatory food chain –** Most of food chain in nature are of this type. This food chain begins with **producers** (plants) and in successive order it goes from **small organism to big organism**.



(ii) **Parasitic food chain –** This food chain also starts from **producers** but in successive order it goes from **big organism to the smaller organism**.

e.g. Tree ecosystem –



Note : Both above food chains are directly dependent on **solar radiation** (as a primary source of energy) and have **rapid energy flow**.

(iii) **Detritus food chain or Saprophytic food chain –** This food chain begins with decomposition of dead organic matter by **decomposers** so it is also known as saprophytic food chain. In this food chain primary consumers are bacteria and fungi.
Dead organic matter → bacteria, fungi

Note :

- In detritus food chain **energy flow** is rather very slow yet **magnitude** of energy is great.
- In mangrove vegetation this food chain goes up to big organism.
  Dead mangroves leaves → Bacteria & fungi → Aphids, molluscs, crabs, nematodes → Small fishes → Tiger.

- In an aquatic ecosystem, **GFC (Grazing Food Chain)** is the major conduit (source) of energy flow. As against this, in a terrestrial ecosystem, a much larger fraction of energy flow through the **(DFC) Detritus food chain** than through the grazing food chain.

Special points of Biotic Factors :

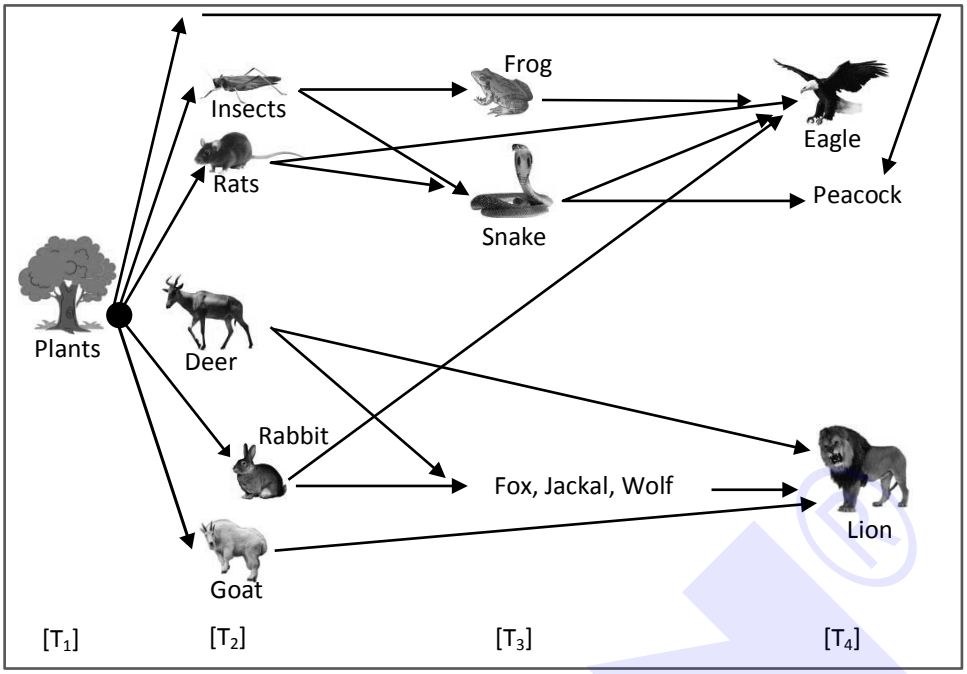
- In Sunderbans, Tigers feed on the fishes and crabs in the absence of their natural prey.
- **Nutrient Immobilisation -** In the process of decomposition, some nutrients get tied up with the biomass of microbes and become temporarily unavailable to other organisms. Such incorporation of nutrient in living microbes (bacteria & fungi) is called **nutrient immobilisation.**
- In aquatic ecosystem **whale** is secondary consumer. It is an example of **filter feeder** because it feeds on planktons.
- **Plant parasites** are known as primary consumers while **animals parasites** (*E.coli* bacteria, *Entamoeba histolytica*, liver fluke, tapeworm) are known as secondary consumers.
- **All the insectivorous** plants play the double role i.e. producer as well as secondary consumer because they synthesise their own food through photosynthesis and they eat insects simultaneously.
- **Man, Peacock, Cockroach, Crow, Sparrow & Fish** are omnivores.
- Organisms which use **milk** or curd as food, are known as secondary consumer.

  Note : Inorganic materials (CO_2 ,H_2O, Light), autotrophs (**Producers**) and **decomposers** are essential in ecosystem but, **macro consumers** are non essential.
- **Guild** $\rightarrow$ Members of same trophic level.

(E) Food Web :

In large ecosystem many food chains are interlinked together at different trophic levels to form food web. In food web transfer of food energy is unidirectional but from many different alternative pathway.

In food web members of a particular trophic level obtain their food according to their choice and taste but this facility is not present in food chain. It means organisms have more than one option or alternatives for getting food in food web.



As much as food web is complex that ecosystem is more stable or permanent, such type of ecosystem is not destroyed naturally and continues for long time. This ecosystem is not affected by loss of any organism of any particular trophic level. **Those ecosystems which have simple food web are not very stable** it means that they can be disrupted at any time, if there is a change in any particular trophic level.

(F) Homeostasis :

Ecosystems is dynamic (functional) system in which continuous interactions among biotic and abiotic components are present to maintain equilibrium.

Ecosystem is self sustainable and self regulatory system.

Such equilibrium is also established among different trophic levels. This property of ecosystem is called homeostasis.

(G) Ecological pyramids :

Graphical representation of ecological parameters at different trophic level in ecosystem is called pyramids. These parameters are Number, Biomass and Energy. Concept of ecological pyramids was given by **Charles Elton**, hence also called Eltonian pyramids.

In pyramids basal, mid and top tiers show the parameter values for producer, herbivores and carnivores in the ecosystem.

These pyramid are of three types

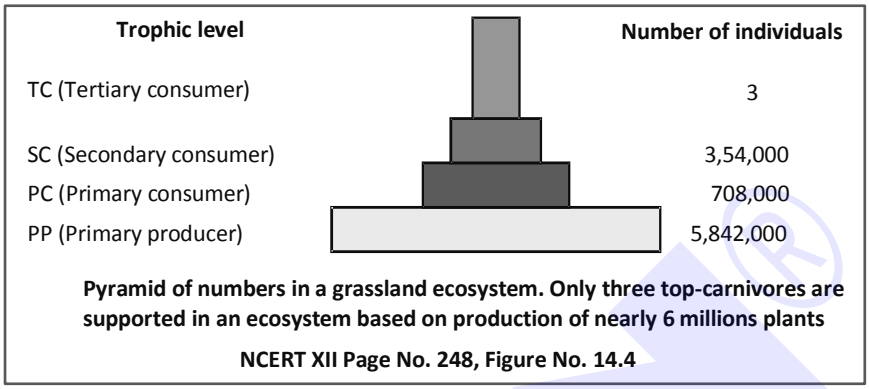
(i) Pyramids of number

(ii) Pyramids of biomass

(ii) Pyramids of energy

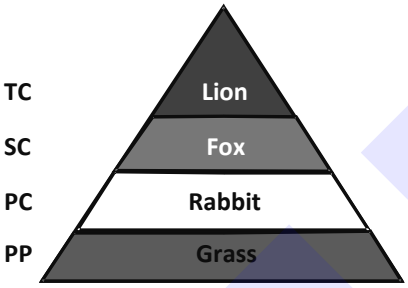
(i) Pyramids of number –

In this type of pyramid the number of individual organism in various trophic level is shown. These pyramids are mostly upright, because number of producers [T_1] is maximum and No. of herbivores and carnivores decrease towards apex or at successive trophic levels, such as Grassland ecosystem and aquatic ecosystem.

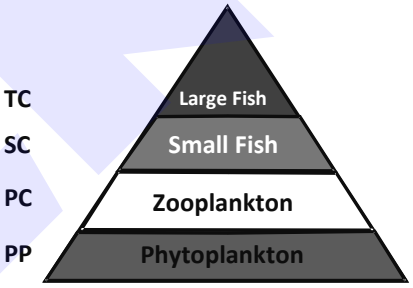


Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants

NCERT XII Page No. 248, Figure No. 14.4

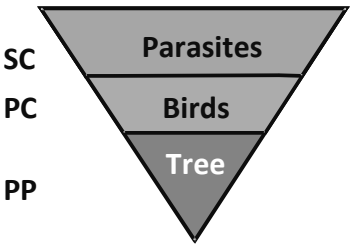


Grassland Ecosystem



Aquatic Ecosystem

But in a tree ecosystem the pyramid of numbers is inverted. This is called parasitic ecosystem because birds (herbivores) depend on the tree (producer) and parasites (consumer) depend on birds, therefore with increase in the no. of trophic levels, the number of the organisms increases sequentially.



Tree Ecosystem

Note:

- Pyramid of number represents **biotic potential** at a trophic level.
- Maximum number of producers are present in aquatic ecosystem. **The number of organism at any trophic level depends upon the availability of organism which are used as food** on lower level so availability of food is main factor.

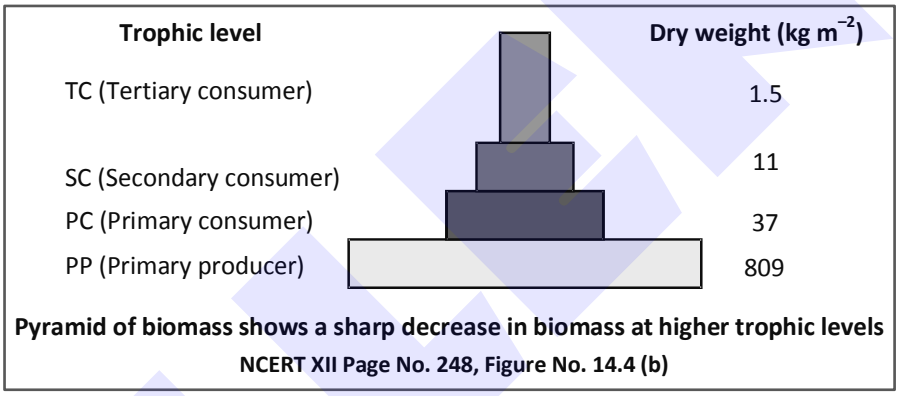
- If on a big tree, large number of insects feed followed by a number of small birds depending on the insects and large birds eating smaller birds.

  Draw the shape of pyramid you would get.

(ii) Pyramid of Biomass –

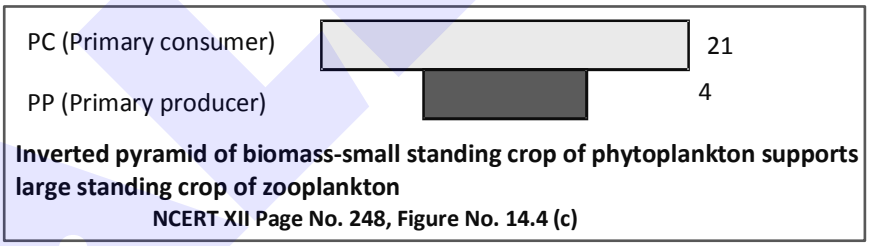
Pyramids of biomass represent the total amount of biomass of each trophic level of ecosystem, these pyramids are mostly upright (erect) e.g. (tree ecosystem), forest ecosystem.

Note : The pyramids of biomass represents the **standing crop**.



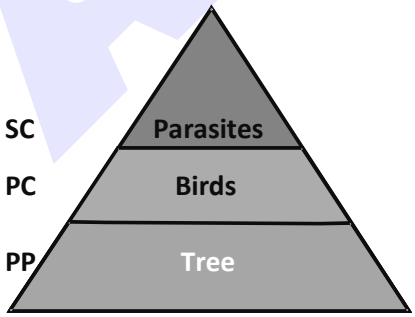
Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels

NCERT XII Page No. 248, Figure No. 14.4 (b)

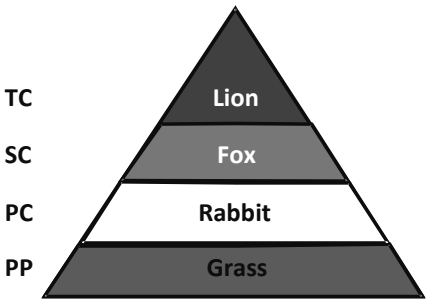


Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton

NCERT XII Page No. 248, Figure No. 14.4 (c)

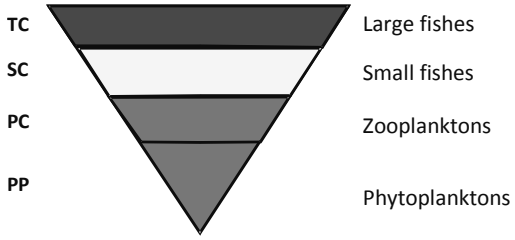


Tree Ecosystem

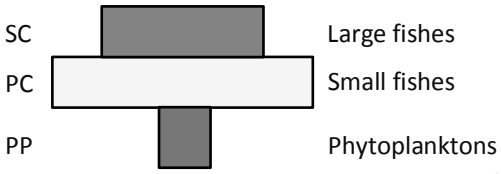


Grassland Ecosystem

Pyramids of biomass in **aquatic ecosystem** is inverted because in it producers are micro-organism and their biomass is very less.

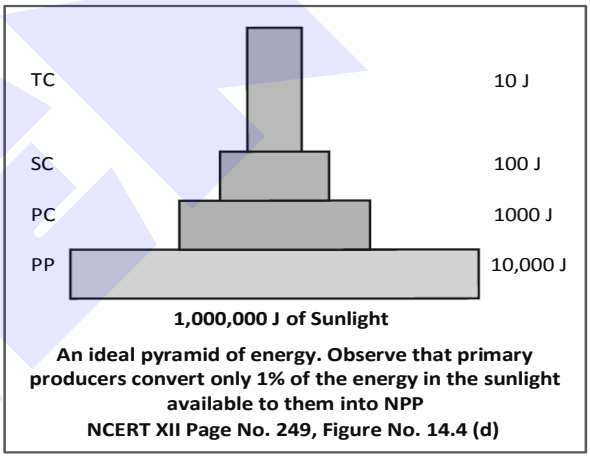


Note : Pyramid of biomass in lake ecosystem.



(iii) Pyramids of energy –

Pyramid of energy is always upright, can never be inverted, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step. Each bar in the energy pyramid indicates the amount of energy present at each trophic level in a given time or annually per unit area.



An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP
NCERT XII Page No. 249, Figure No. 14.4 (d)

According to the **10% law of Lindeman**, the 90% part of obtained energy of each organism is utilized in their various metabolic activities and heat and only 10% energy is transferred to the next trophic level. So 90% energy is lost at each trophic level, therefore **top consumers like lion etc. are ecologically weakest** but physically they are strong.

Note : Pyramids of energy represent the productivity as well as transfer of production in ecosystem.

Limitations of Ecological Pyramids –

- It does not take into account the same species belonging to two or more trophic levels.
- It assumes a simple food chain, something that almost never exists in nature. It does not accommodate a food web.
- Saprophytes are not given any place.

Some Special point :

- **Standing crop –** Total amount of **living organic matter** present in particular area in particular time in an ecosystem is known as standing crop. Standing crop is measured as mass of living organisms or number in a unit area.

  Biomass is the standing crop expressed in terms of weight (i.e. organism mass). Biomass is measured by **bombcalorimeter.**

- **Standing quality or Standing state** – Total amount of **inorganic substances** such as C, P, Ca etc. present in soil at a particular time in an ecosystem is known as standing state.

(H) Productivity :-

There are two type of productivity present

(i) Primary productivity –

Primary production is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. It is expressed in terms of weight (g/m^2) or energy ($Kcal\ m^{-2}$). The rate of biomass production is called productivity. It is expressed in terms of $g\ m^{-2}\ yr^{-1}$ or $(Kcal\ m^{-2})\ yr^{-1}$ to compare the productivity of different ecosystem.

It is of two types :

(a) Gross primary productivity (G.P.P.) – It is the total amount of energy fixed (organic food) in an ecosystem (in producers) in unit time is called G.P.P. including the organic matter used up in respiration during the measurement period. It is also known as total (Gross) photosynthesis. A considerable amount of GPP is utilised by plants in respiration.

(b) Net primary productivity (N.P.P.) – It is the amount of stored organic matter in plant tissues after respiratory utilisation

NPP = GPP – R (R = Respiration / Metabolic activities)

or

GPP = NPP + R

NPP is the available biomass for the consumption to heterotrophs.

(ii) Secondary productivity – Sec. productivity is the rate of formation of new organic matter by consumers.

Note : Net community productivity or Net productivity –

The rate of storage of organic matter not used by the heterotrophs

NCP = N.P.P. – HR (HR = Energy used by Heterotrophs)

- During Succession net community productivity or annual yield decreases.

Some informations related to productivity –

- Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors availability of nutrients and photosynthetic capacity of plants. Therefore it varies in different type of ecosystem. The annual net primary productivity of the whole biosphere is approximately **170 billion tons** (dry weight) of the organic matter, productivity of the ocean are only **55 billion tons**.
- Among terrestrial ecosystems maximum productivity found in **tropical rain forest.**
- In water, least productive ecosystem is very deep lakes and highly productive ecosystem is coral reef.
- Limiting factor for productivity in ocean is nitrogen and in lake is phosphorus.

Golden Key Points

- The boundaries of ecosystem are indistinct and have a overlapping character over each other.
- Natural ecosystem show high stability as compare to artificial ecosystem due to high species diversity.
- During photosynthesis primary producers absorb solar energy and convert it into chemical energy so producers are also called **transducer** or **converters.**
- Decomposers play a significant role in mineral cycle so that presence of decomposers is essential for stability or existence of ecosystem.
- There are two basic function of ecosystem (i) Energy flow (ii) Nutrient cycling
- Ecosystem are not exempt from the second law of thermodynamics.
- Tertiary consumer is present in between the secondary consumer and top consumer.
- Generally the decomposers (Bacteria/Fungi) are not included in the food chain but when included then included as the last trophic level.
- Pyramid of number shows biotic potential, Pyramid of biomass show the standing crop and Pyramid of energy represent the productivity.
- **Net primary productivity (NPP)** is the available biomass for the consumption to heterotrophs.

BEGINNER'S BOX

BIOTIC COMPONENT, FOOD CHAIN, FOOD WAVE, ECOLOGICAL PYRAMID, PRODUCTIVITY

1. Grass → Deer → Tiger

In this food chain, the biomass of grass is 1 tonne. The tiger biomass will be :

(1) 100 kg (2) 10 kg (3) 1 kg (4) 1000 kg

2. An ecosystem is a complete interaction of :

(1) Individual

(2) Population

(3) Community and their soil condition

(4) Community and their physical environment

3. What is correct for transducers :

(a) They convert solar energy into chemical energy

(b) Placed at first trophic level

(c) They are osmotrophs

(d) Show nutrient immobilization

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

4. Ecosystem resists change because it shows:

(1) Imbalance (2) Homeostasis

(3) Deficient component (4) Affected by light

5. On Earth in per unit area maximum productivity occur in :

(1) Tropical rain forest

(2) Ocean

(3) Temperate deciduous forest

(4) Marsh

6. In which of the following ecosystem pyramids are always upright ?

(1) Tree ecosystem (2) Lake ecosystem

(3) Grass land ecosystem (4) All of above

7. On the basis of ecology which is not essential for self sustaining ecosystem :

(1) Producer (2) Macro-consumers

(3) Micro-consumers (4) All of above

8. Which of the following is not recycled in an ecosystem :

(1) Water (2) Carbon (3) Energy (4) Nitrogen

(I) Light

- It is a complex physical environmental factor. Light is measured by **luxmeter or photometer.** It is a electromagnetic spectrum.
- **Solar Constant –** Solar radiation before entering the atmosphere carries energy at a constant rate i.e., 2 cal cm^{-2} min^{-1} known as the solar constant.
- In solar radiation wavelength (λ) of light or visible spectrum is 0.4 to 0.7 μm (400–700 nm) it is also called **photosynthetically active radiation (PAR).**

The U. V. radiation distinguished in

U. V. – C $\rightarrow$ (0.100 to 0.280 μm)

U. V. – B $\rightarrow$ (0.280 to 0.320 μm)

U. V. – A $\rightarrow$ (0.320 to 0.400 μm)

Albedo value –

The ability of a surface to reflect the incoming radiation is called albedo value (AV) it is **80%** for fresh snow, **20-30%** for sand, **5-10%** for the forest.

- Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth. Of the incident solar radiation (ISR) less than **50 per cent** of it is **photosynthetically active radiation (PAR).** Plants capture only **2-10 per cent** of the PAR and this small amount of energy sustains the entire living world.
- Many species of small plants (herbs and shrubs) growing in forests are adapted to photosynthesise optimally under very low light conditions because they are constantly overshadowed by tall, canopied trees. Many plants are also dependent on sunlight to meet their photoperiodic requirement for flowering.
- For many animals too, light is important in that they use the diurnal and seasonal variations in light intensity and duration (photoperiod) as cues for timing their foraging, reproductive and migratory activities.
- The availability of light on land is closely linked with that of temperature since the sun is the source for both. But, deep (>500m) in the oceans, the environment is perpetually dark and its inhabitants are not aware of the existence of a celestial source of energy called Sun. What, then is their source of energy ?

Hydrothermal vents – These are hot water springs in the deep ocean having high concentration of H_2S. Chemosynthetic bacteria oxidizes H_2S producing energy which is used for preparing their own food. Filter-Feeders (clams) eat these bacteria so that this food chain based on chemical energy.

(J) Temperature

Temperature is measured by the **thermometer** and under water by **thermistor.**

- **Temperature is the most ecologically relevant environmental factor.**
- The average temperature on land varies seasonally, decreases progressively from the equator towards the poles and from plains to the mountain tops.
- It ranges from subzero levels in polar areas and high altitudes to >50°C in tropical deserts in summer.
- There are, however, unique habitats such as thermal springs and deep-sea hydrothermal vents where average temperatures exceed 100°C.
- It is general knowledge that mango trees do not and cannot grow in temperate countries like Canada and Germany, snow leopards are not found in Kerala forests and tuna fish are rarely caught beyond tropical latitudes in the ocean.
- Temperature affects the kinetics of enzymes and through it the basal metabolism, activity and other physiological functions of the organism.

(i) Adaptation :-

Adaptation is any attribute of the organism (morphological, physiological, behavioural) that enables the organism to survive and reproduce in its habitat.

Many adaptations have evolved over a long evolutionary time and are genetically fixed.

(a) Morphological adaptations :-

In Animals : Temperature affect the absolute size of an animal and its body parts.

Bergman's rule –

Birds and mammals attain greater body size in cold region and lesser in warm region.

Allen's rule –

Mammals from colder climates generally have shorter ears and limbs to minimise heat loss. (This is called the **Allen's Rule**.)

Heat loss or heat gain is a function of surface area. Since small animals have a larger surface area relative to their volume, they tend to lose body heat very fast when it is cold outside; then they have to expend much energy to generate body heat through metabolism. This is the main reason why very small animals are rarely found in polar regions.

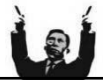
In Plants —

Some desert plants like ***Opuntia*** have no leaves. Leaves modified into spines to reduce transpiration the photosynthetic function is taken over by the flattened stems.

Many desert plants have a thick cuticle on their leaf surfaces and have their stomata arranged in deep pits to minimise water loss through transpiration.

(b) Physiological Adaptations :-

- In the polar seas aquatic mammals like seals have a thick layer of fat (blubber) below their skin that acts as an insulator and reduces loss of body heat.
- They also have a special photosynthetic pathway (CAM) that enables their stomata to remain closed during day time
- **Anti freezing protein** compounds allow the fishes in Antarctica region to remain active in polar water.
- Many xerophytes may accumulate **proline** (an amino acid) in their cells to maintain osmotic and water potential in their leaves.
- The heat shock protein **(chaperonins)** provide physiological adaptations to plants to high temperature. This protein help other protein to maintain their structure and avoid denaturation at high temperature.
- In the absence of an external source of water, the kangaroo rat in north American deserts is capable of meeting all its water requirements through its internal fat oxidation (in which water is a by product). It also has the ability to concentrate its urine so that minimal volume of water is used to remove excretory products.



Acclimatisation –

Acclimatisation is a gradual **physiological adjustment** of the organism to the slowly changing new environmental condition. If there is a shift in some environmental factor beyond the tolerance range of an organism the latter can come to the resting stage or migrate.

Some organisms posses adaptations that are physiological which allow them to respond quickly to a stressful situation. If we go high altitude place we experienced what is called **altitude sickness**. Its symptoms include nausea, fatigue and heart palpitations. This is because in the low atomospheric pressure of high altitudes, the body does not get enough oxygen. (Our body solve this problem - The body compensates low oxygen availability by increasing red blood cell productions, decreasing the binding capacity of haemoglobin and by increasing breathing rate.) Many tribes live in the high altitude of Himalyas have a higher red blood cell than people living in the plains. The tribes are adapted genetically to such high altitude condition.

(c) Behavioural Adaptations

- **Suspension**

  Hibernation (Winter sleep) - Winter sleep or period of dormancy

  Cold blooded animals - e.g. Amphibians, reptiles

  Hot blooded animals - e.g. Polar bear, North ground squirrels

  Aestivation (Summer sleep) - Escape from heat of sun

  e.g. Lung fishes, Snails, Ground squirrels in south-west desert

  Diapause – Under unfavourable conditions many zooplankton species in lakes and ponds are known to enter diapause, a stage of suspended development.

- **Migration**

Some examples of migration (behavioural adaptation)

Type of migration	Examples	Activities
Long-distance	Arctic tern, Siberian crane	● Nests close to north pole in summer. Flies from North (Arctic) to Antarctica in autumn and returns to North pole again each spring.
Short-distance	Caribou, Elk and whale	● Migrates in search of food each winter to warmer place.
Periodic	Locust (Tiddi)	● Large population migrate in search of feeding grounds.

Note : Thermal Migration – Thermal migration has been seen in birds (siberian cranes, arctic tern), mammals (Bison, caribou), fishes (salmon) etc.

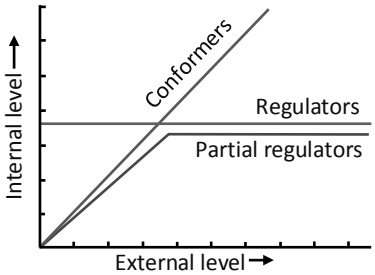
- Some organisms show behavioural responses to cope with variations in their environment. Mammals have to deal with the high temperatures of their habitat, but manage to keep their body temperature fairly constant by behavioural means.
- **Desert lizards** lack the physiological ability. They bask in the sun and absorb heat when their body temperature drops below the comfort zone, but move into shade when the ambient temperature starts increasing. Some species are capable of burrowing into the soil to hide and escape from the above-ground heat.

(ii) Response to abiotic factors :-

A few organisms can tolerate and thrive in a wide range of temperatures (they are called **eurythermal**), but, a vast majority of them are restricted to a narrow range of temperatures (such organisms are called **stenothermal**). The levels of thermal tolerance of different species determine to a large extent their geographical distribution.

Regulators :

- Some organisms are able to maintain homeostasis by physiological (sometimes behavioural also) means which ensures constant body temperature, constant osmotic concentration, etc.
- All birds and mammals, and a very few lower vertebrate and invertebrate species are indeed capable of such regulation (thermoregulation and osmoregulation).



Diagrammatic representation of organismic response
NCERT Page No.223, Figure No.13.3

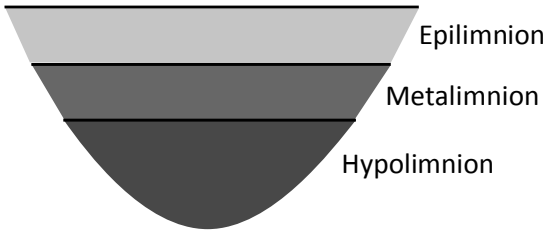
- **Evolutionary biologists believe that the 'success' of mammals is largely due to their ability to maintain a constant body temperature** and thrive whether they live in Antarctica or in the Sahara desert.
- The mechanisms used by most mammals to regulate their body temperature are similar to the ones that we humans use. We maintain a constant body temperature of 37°C. In summer, when outside temperature is more than our body temperature, we sweat profusely. The resulting evaporative cooling, similar to what happens with a desert cooler in operation, brings down the body temperature. In winter when the temperature is much lower than 37°C, we start to shiver, a kind of exercise which produces heat and raises the body temperature.
- Plants, on the other hand, do not have such mechanisms to maintain internal temperatures.

Conformers :

- Organism who cannot maintain a constant internal environment means their body temperature or osmotic concentration change with external environment.
- An overwhelming **majority (99 per cent) of animals** and nearly all plants cannot maintain a constant internal environment. Their body temperature changes with the ambient (atmospheric) temperature. In aquatic animals, the osmotic concentration of the body fluids change with that of the ambient (surrounding) water osmotic concentration. These animals and plants are simply conformers.
- Considering the benefits of a constant internal environment to the organism, we must ask why these conformers had not evolved to become regulators. Recall the human analogy we used above; much as they like, how many people can really afford an air conditioner? Many simply 'sweat it out' and resign themselves to suboptimal performance in hot summer months.
- **Thermoregulation is energetically expensive for many organisms.** This is particularly true for small animals like shrews and humming birds.

(iii) Thermal stratification in lakes :-

Thermal stratification occurs in deep water body because of difference in temperature of water at different depth. Mainly three layer or zone occurs in lake below (like in summer)



- **Epilimnion –**

  The top layer gains warmth.

- **Metalimnion/thermocline –**

  Middle region steady decline in temperature or a gradual change in temperature.

- **Hypolimnion –**

  Bottom which is not affected by temperature.

(K) Soil or edaphic factor :-

Soil is the uppermost layer of earths crust formed by weathering of rocks. It is the mixture of living or non living materials.

- The nature and properties of soil in different places vary; it is dependent on the climate, the weathering process, whether soil is transported or sedimentary and how soil development occurred.
- Various characteristics of the soil such as soil composition, grain size and aggregation determine the percolation and water holding capacity of the soils.
- These characteristics along with parameters such as pH, mineral composition and topography determine to a large extent the vegetation in any area. This in turn dictates the type of animals that can be supported.
- Similarly, in the aquatic environment, the sediment-characteristics often determine the type of benthic animals that can thrive there.

Minerals 45% + **Water 25%** + **Air 25%** + **Organic matter** (living + non living) **5%**
Soil formation is slow process 1 inch soil is formed in 500-1000 years
Pedogenesis – development of soil or soil formation
Pedology (Edaphology) – study of soil

(i) Soil mineral matter –

As a result of weathering the mineral particles of different size are formed.

Soil Type	Size of particles
Clay	less than 0.002 mm
Silt	0.002 – 0.02 mm
Fine sand	0.02 – 0.20
Coarse sand	0.20 – 2.0
Gravel or Grit	2mm – 5mm
Coarse Gravel	Above 5.00

Sandy Soil	=	85% sand + 15% clay or silt or both
Loamy Soil	=	50% sand + 50% clay or silt or both
Silt Soil	=	90% silt + 10% sand

Note : Loam Soil is the **best soil** for growing of crops due to high water holding capacity, high aeration and high root penetration.

(ii) Soil organic matter

The dead organic matter present in soil is called humus, which is formed by decomposition of plant and animal remains. Freshly fallen plant and animal material called detritus or **litter**, partially decomposed litter is called **duff**. Fully decomposed litter is called **humus**.

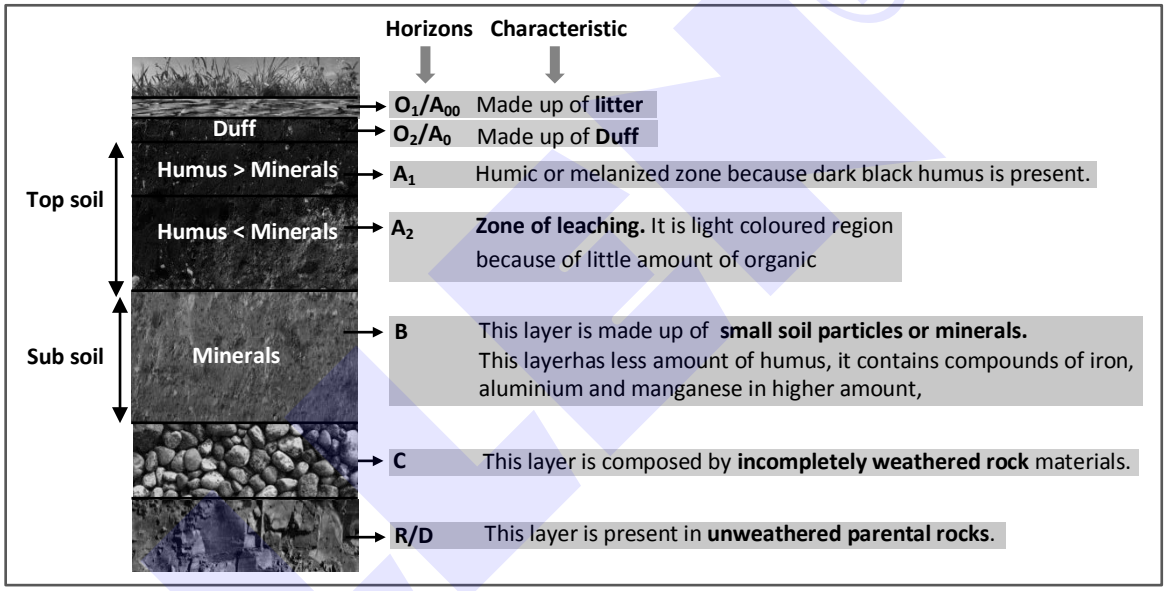
Litter → Duff → Humus

Decomposition (Formation of Humus) :

- Decomposers break down complex organic matter into simple organic matter (humus) and inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition.
- Dead plant remains such as leaves, bark, flowers and dead remains of animals, including fecal matter, constitute detritus, which is the raw material for decomposition.
- The important steps in the process of decomposition are **fragmentation, leaching, catabolism, humification and mineralisation.**
- **Detritivores (e.g. earthworm)** break down detritus into smaller particles. This process is called fragmentation. By the process of leaching, water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.
- Bacterial and fungal enzymes degrade detritus into simple organic and inorganic substances, This process is called as **catabolism**.
- It is important to note that all the above steps in decomposition operate simultaneously on the detritus.
- **Humification and mineralisation** occur during decomposition in the soil.
- Humification leads to accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. Being colloidal in nature it serves as a reservoir of nutrients.
- The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as **mineralisation**.

- Decomposition is largely an **oxygen-requiring** process.
- The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition, decomposition rate is slower if detritus is rich in lignin and chitin, and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars.
- **Temperature** and **soil moisture** are the most important climatic factors that regulate decomposition though their effects on the activities of soil microbes. Warm and moist enviroment favour decomposition wheres low temperature and an anaerobiosis inhibit decompositon resulting in build up of organic materials.

(iii) Soil profile



Note :

- **Best pH** of the soil for cultivation of plant is **5.5 – 6.5**
- Excess irrigation produce **water logging** and **salinity** in soil
- **Ley Farming** – A system of rotating crops with legume or grass pasture to improve soil structure and fertility.

(L) Water

- Next to temperature, water is the most important factor influencing the life of organisms.
- You might think that organisms living in oceans, lakes and rivers should not face any water-related problems, but it is not true. For aquatic organisms the quality (chemical composition, pH) of water becomes important.
- The salt concentration (measured as salinity in parts per thousand), is less than **5 PPT** in inland waters, **30-35 PPT** the sea and more then **100 PPT** in some hypersaline lagoons.

- Some organisms are tolerant of a wide range of salinities (**euryhaline**) but others are restricted to a narrow range (**stenohaline**).
- Many freshwater animals cannot live for long in sea water and vice versa because of the osmotic problems, they would face.

(M) Topography

It includes the physical features of the earth like altitude, slope, exposure, mountain chains valleys plants. It affects distribution of organism by influencing the climatic factor like light, wind, rainfall etc.

Golden Key Points

- Geographical distribution of different species is determined by the level of thermal tolerance.
- The availability of light on land is closely linked with temperature since the sun is the source of for both.
- In aquatic environment, the sediment characteristics often determine the type of benthic animals that can thrive there.
- Under unfavourable conditions many zooplankton species in lakes and pond are known to enter diapause, a stage of suspended development.

BEGINNER'S BOX — ABIOTC COMPONENT OF ECOSYSTEM AND ADAPTATIONS IN ORGANISMS

1. A majority of organisms which are restricted to a narrow range of temperature are called as :

(1) Stenothermal (2) Endothermal

(3) Homeothermal (4) Eurythermal

2. Percolation and water hodling capacity of soil is dependent upon :

(1) Soil composition (2) Grain size

(3) Aggregation (4) All of these

3. Which of the following is not the stage of suspension ?

(1) Migration (2) Hibernation

(3) Aestivation (4) Diapause

4. Seals have a thick layer of fat (blubber) below their skin that act as an :

(1) Thermostat (2) Capacitor (3) Resistor (4) Insulator

5. The salinity in sea water in parts per thousand (ppt) ranges between :

(1) 5–15 (2) 30–35 (3) 50–75 (4) More than 100

6. To avoid summer related problems such as heat and dessication fish undergoes :

(1) Hibernation (2) Diapause (3) Aestivation (4) Dormancy

(N) Bio-Geo Chemical Cycle or Nutrient Cycle

Bio – Living organism

Geo – Rock, Soil, Air, Water

Chemical – Mineral or Nutrients

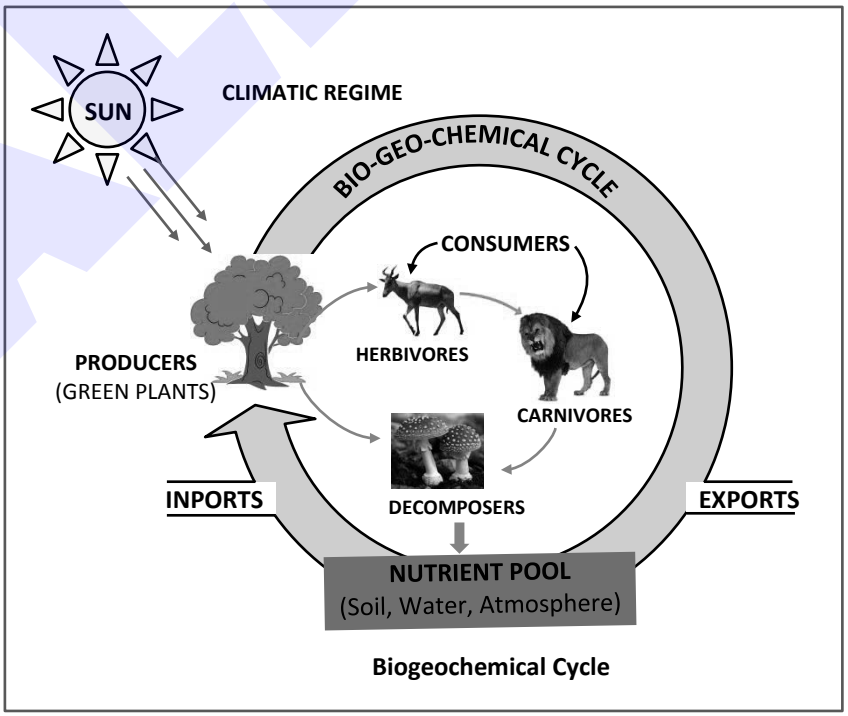
Cycle – Path

- Nutrients which are never lost from the ecosystems, are recycled again indefinitely through the various components of an ecosystem is called nutrient cycling or biogeochemical cycle.
- Thus there is a constant exchange of materials between the living organism and their abiotic environment through the recyling of materials.
- **Environmental factors, e.g., soil, moisture, pH, temperature etc., regulate the rate of release of nutrients into the atmosphere.**
- The reservoir function is to fulfill the deficit in biogeochemical cycle created by imbalance between Influx and efflux.

Types of nutrient cycles are found in an ecosystem :

- **Gaseous Cycle –** e.g. C, H, N, O cycles. Reservoir is atmosphere (air) or Hydrosphere (water).
- **Sedimentary cycle –** e.g. P, S, Ca cycles. Reservoirs is earth's crust/lithosphere.

Note : In these cycles, the bulk material remains in the inactive reservoir on earth crust like sediment of sea, or water bodies.

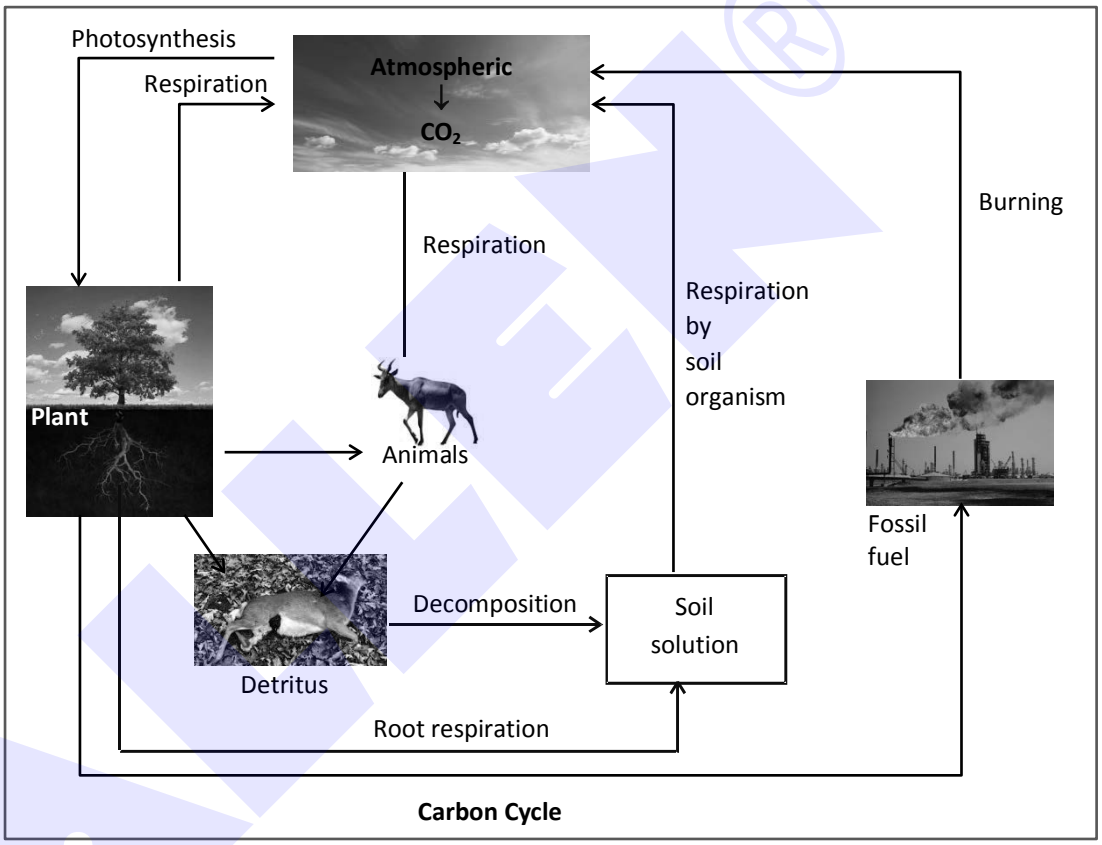


Biogeochemical Cycle

(i) Gaseous Cycle

Carbon Cycle :-

Main reservoir of carbon are **atmosphere, Ocean, Carbonate, Rocks, Coal** and **Petroleum.** The carbon released from them is present in the atmosphere in the form of carbondioxide. Carbon is present in every organic component of organism. The green autotrophs utilize CO_2 from the air to synthesize food materials which is obtained by other organisms as food. Carnivores obtain their organic food from the herbivores. These organic matter produce CO_2 through the oxidation or respiration which dissolve in air or water and again utilized by the plants.



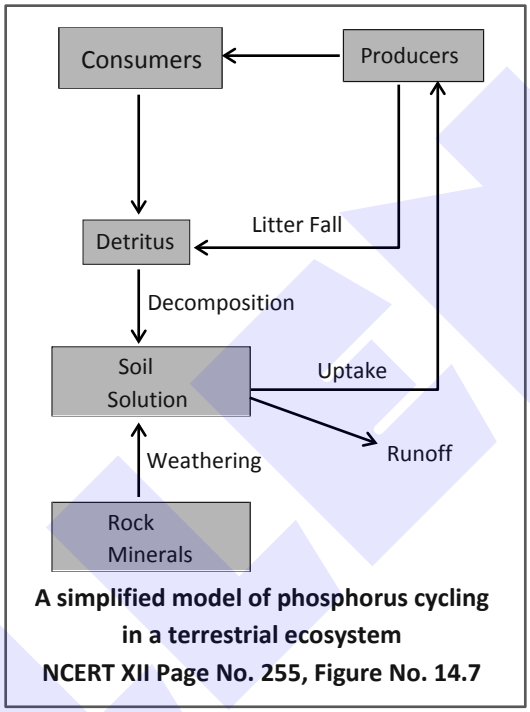
Carbon Cycle

- Carbon constitutes **49%** of **dry weight** of organisms and is next only to water. Atmosphere only contains about **1%** of total global carbon.
- If we look at the total quantity of global carbon, we find that **71 per cent** carbon is found dissolved in oceans. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere.
- Carbon cycling occurs through atmosphere, ocean and through living and dead organisms.
- According to one estimate **4×10^{13} kg** of carbon is fixed in the biosphere through photosynthesis annually.

(ii) Sedimentary Cycle

Phosphorus cycle :-

Main source of phosphorus is **rocks** which contains phosphorus in form of phosphates. When rocks are weathered plants absorb this phosphrous from the soil and transfer this phosphate to animals and after the death of animals it is released again into the lithosphere by the action of decomposers (Phosphate-solubilising bacteria). Phosphorus is the main constituent of protoplasm, biological membranes, bones, teeth, nucleic acids, ATP etc.



A simplified model of phosphorus cycling in a terrestrial ecosystem
NCERT XII Page No. 255, Figure No. 14.7

Sometimes some of the elements like phosphorus and calcium reach into the sea through water, from where they transform into rocks. They separate from the cycle for a long time so it is also known as **sedimentary cycle.**

But when these rocks are weathered this phosphorus is again made available to the sea plant or sea weeds, which pass into fish and sea birds. The excretory materials of birds on the rocks of sea shore is called **Guano** and it is a source of phosphorus.

Note :- Plants absorb phosphate from the soil in the form of orthophosphate (PO_4^{3-}) or $H_2PO_4^-$ or $H_2PO_4^{2-}$.

Difference between Carbon and Phosphorus cycle

- Atmospheric inputs of phosphorus through rainfall are much smaller than carbon.
- Gaseous exchanges of phosphorus between organism and environment are negligible.

Ecosystem Services :-

- Healthy ecosystems are the base for a wide range of economic, environmental and aesthetic goods and services. The products of ecosystem processes are named as **Ecosystem services**, for **example**, healthy forest ecosystems purify air and water, mitigate (minimise) droughts and floods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values.
- Though value of such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a **hefty (bulk) price tag.**
- **Robert Constanza** and his colleagues have very recently tried to put price tags on nature's life-support services.
- Researchers have put an average price tag of **US $ 33 trillion** a year on these fundamental ecosystems services, which are largely taken for granted because they are free.
- This is nearly twice the value of the global gross national product GNP which is **(US $ 18 trillion).**
- Out of the total cost of various ecosystem services, the soil formation accounts for about **50 percent**, and contributions of other services like recreation and nutrient cycling, are less **than 10 percent** each. The cost of climate regulation and habitat for wildlife are about **6 percent** each.

(5) TERRESTRIAL BIOMES

Large ecosystem is called biome. Mainly large aquatic and terrestrial ecosystem are called biomes.

- In each biome climax community is uniform and each biome is identified by its climax community.
- Altitude and latitude determine the boundary of biome.
- Regional and local variations within each biome lead to the formation of a wide variety of habitats.

(A) Biome Distribution :-

(i) Altitude :

Height above the sea surface of any place.

The temperature and species diversity decreases on increasing altitude.

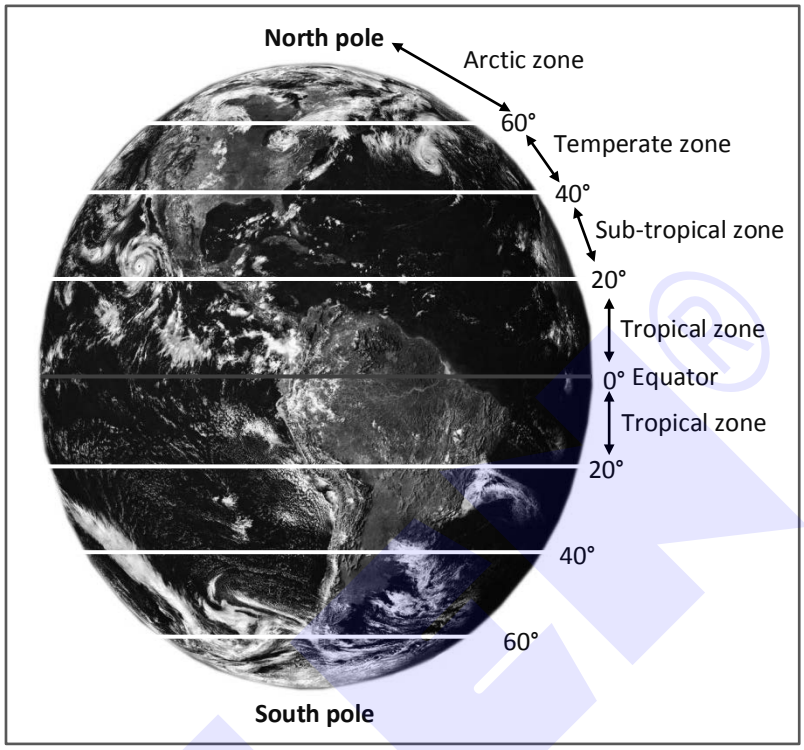
(ii) Latitude :

The distance of any place from the equator

The temperature, light intensity and species diversity are maximum at the equator and decreases gradually towards the pole.

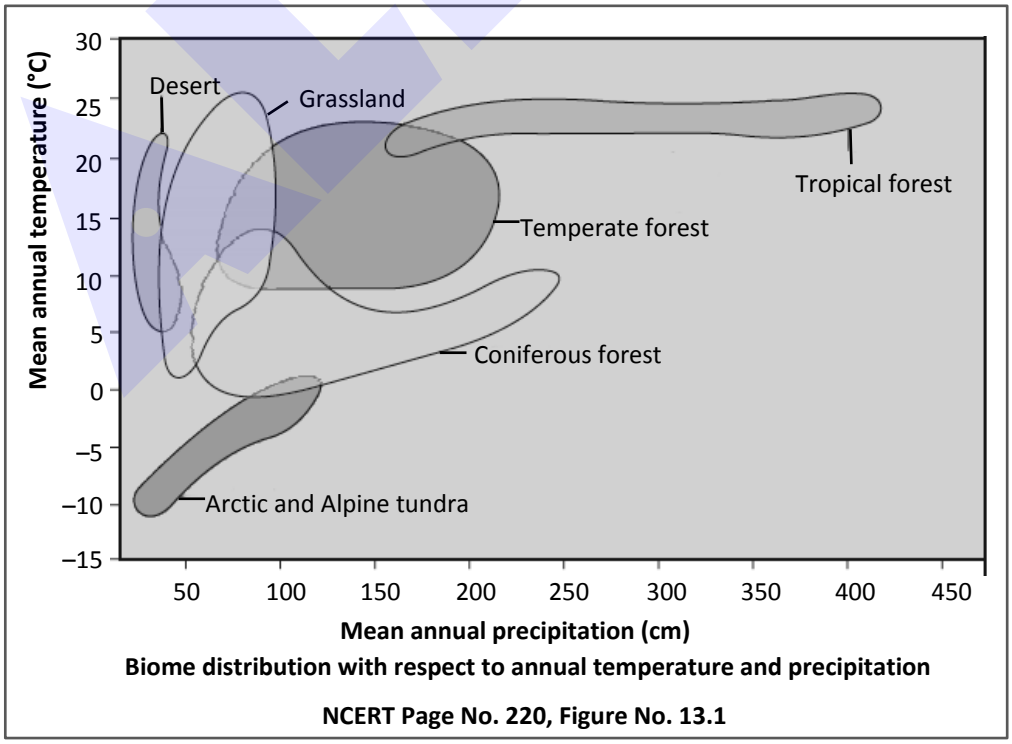
On the basis of variation in mean temperature along latitude the main climatic regions are

- **Tropical** = $0^0 - 20^0$ latitude
- **Subtropical** = $20^0 - 40^0$ latitude
- **Temperate** = $40^0 - 60^0$ latitude
- **Arctic and antarctic** = $60^0 - 80^0$ latitude



Note :

- Effect of altitude and latitude are almost same on temperature.
- The types of vegetation from sea level to measuring altitudes are similar to increasing latitude (distance from equator)



Biome distribution with respect to annual temperature and precipitation

NCERT Page No. 220, Figure No. 13.1

(B) Types of Biome :-

(i) Tundra Biome :

This region lies above 60° North latitude (or North of timber line or tree line) is known as Tundra. **(Timber line – Line beyond which trees are not found)**. In this region soil is covered by snow and ice **(perma frost)** almost whole year.

- At 3600 m height of Himalayas called Alpine tundra.
- The annual rain fall is low and generally below 25 cm/year.

Vegetation – Lichens, Mosses, Grasses, Rhododendron etc.

Note :

- This biome is without trees so it is called **tree less biome**.
- The trees and shrubs are absent in this biome so it is also known as Arctic desert. It is most **delicate** and **fragile biome**.

(ii) The northern coniferous or Needle-leaf forest :

The northern or temperate coniferous forest is also known as **Taiga** or **North wood**. It is situated immediate south of the Tundra.

- Distributed over 1700 to 3000 m altitude in himalaya.
- The evergreen temperate forests are found on Himalaya.
- Taiga is largest terrestrial biome on earth.

Vegetation – Pinus, Deodar etc.

(iii) The Temperate Deciduous Forest :

- The deciduous forest lies in temperate zone about 40^0–60^0 N latitude and 1500 - 2400 m altitude central location.

Vegetation – Broad leaved forest which includes **oak (*Quercus*)**

Note :- The trees shed their leaves in autumn and bear again in spring.

(iv) Tropical Deciduous Forest :

Occurs widely in the northern and southern part of our country in plain and low hilly area.

- Leaves of most of the trees fall before the summer.

Vegetation – Sal (*Shorea robusta*), **Teak** (*Tectona grandis*), Tendu etc.

(v) The Tropical Rain forest :

The tropical rain forest biome lies on the **equatorial region** around the earth.In India tropical rain forest is found in Eastern Himalaya and Western Ghats. Tropical rain forest are present in Assam, W.Bengal, Kerela and Andman & Nicobar islands in India.

- The main feature of this biome is the large amount of annual rainfall which is more than at least **200-450 cm per year.**
- The tropical rain forest are **richest in flora and fauna.**
- The temperature is high and uniform throughout the year. Climate is warm and humid.

Vegetation – *Dipterocarpus* and *Hopea*.

Generally parasitic plants are found in these places such as - *Cuscuta, Loranthus, Orobanche*, *Rafflesia, Striga* and *Santalum* (Chandan).

In addition of these saprophytic plants also found like *Monotrapa*.

(vi) The Chaparral Biome (Mediterranean Scrub forest) :

The mediterranean forests occur along the pacific coast of **North America, South America and South Africa**.

Vegetation– Fire resistant and **drought resistance** plants, small trees and shrub like sage etc.

(vii) The Tropical Savanna Biome :

The Tropical Savanna biome is located in **equatorial and sub-equatorial regions (Africa, South America, India & Australia).**

- It is also called tropical grassland.
- In this biome grasses are found with few **scattered** tree.

Vegetation – Coarse grass – *Dichanthium, Phragmites,*

Trees – *Acacia, Zizyphus, Prosopis*

(viii) The Grassland Biome :

Name of Grass lands	Place
Prairies	North America
Pampas	South America
Steppes	Europe and Asia (Russia)
Tussocks	Newzealand
Veldts	Africa

(ix) The Desert Biome :

The desert biome stretches in the dry region of the world where there is very little rainfall.

- The deserts are located around the tropic of cancer and tropic of capricorn, between latitude 15^0 to 35^0 north and south.
- The annual rainfall is very less (less than 25 cm).
- Flora and fauna are very less.

The main deserts are the Sahara desert of North Africa, the Thar, Gobi and Tibet desert of Asia.

Sahara – North Africa

Tibet, Gobi, Thar – Asia

Note : Gobi desert is cold desert.

Sahara and Thar are hot desert.

(C) Summary of Biome :-

	Biome	Latitude	Altitude	Vegetation
1.	Tundra (fragile-biome)	Above 60° North	3600 meter height of Himalaya	**Lichen, Moss, Grass** **Note :** ●This biome is tree less and also known as arctic desert or alpine tundra ●Timber line – Line beyond which trees are not found. ●Perma frost – In this region soil is covered by snow or ice.
2.	Northern oniferous or Needle leaf or temperate forest	40° – 60°	1700 to 3000 meter	**Pine (Pinus), Deodar (Cedrus)** **Note :** ●Coniferous forest posses needle like leaves ●This forest also known as Taiga or North wood.
3.	Temperate decidous or broad leaf forest	40° – 60°`	1500 to 2400 meter	**Oak (Quercus)** **Note :** ●Trees shed their leaves in autumn and bear again in spring
4.	Tropical deciduous forest	Occurs widely in the Northern and Southern part of our country in plain and low hilly area.		**Sal (Shorea robusta), Teak (Tectona grandis), Tendu** **Note :** ●Leaves of most of the tree fall before summer.
5.	Tropical rain forest	Tropical rain forest are found at equatorial region around the earth. In India tropical rain forest are distributed mainly along western Ghats and Eastern Himalya (Assam, W. Bengal, Andman, Manipur)		**Dipterocarpus and Hopea are most common tree species in India.** **Lianas are also found.**
6.	Chaparral (Mediterranean) scrub forest	These forest are **found pacific coast of North America, South America and South Africa**		Drought resistant and fire resistant plant species are found eg. Small tree, Shrub (sage)
7.	Tropical Savanna biome (Thorn forest)	Tropical Savanna biome are found in South America, Australia, Africa and India.		**Coarse grass – Dichanthium, Phragmites** **Trees – Acacia, Eucalyptus, Zizyphus, Capparis** **Note :** ● In this biome grass are found with scattered tree.
8.	Grass land biome	**Name of Grass lands**	**Place**	
		Prairies	North America	
		Pampas	South America	
		Steppes	Europe and Asia (Russia)	
		Tussocks	Newzealand	
		Veldts	Africa	
9.	Desert Biome	**Name of desert**	**Place/Area**	
		Sahara	North Africa	
		Tibbet, Gobi, Thar	Asia	
		Note : ●Gobi desert is cold desert ●Sahara and Thar are hot desert		

What is so special about tropics that might account for their greater biological diversity?

Ecologists and evolutionary biologists have proposed various hypotheses; some important ones are

(a) Speciation is generally a function of time, unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes have remained relatively undisturbed for millions of years and thus, had a long. evolutionary time for species diversification,

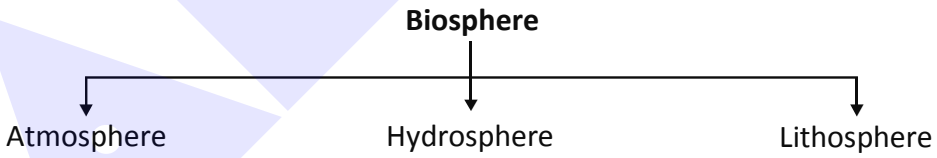
(b) Tropical environments, unlike temperate ones, are less seasonal, relatively more constant and predictable. Such constant environments promote niche specialisation and lead to a greater species diversity.

(c) There is more solar energy available in the tropics, which contributes to higher productivity; this in turn might contribute indirectly to greater diversity.

Note : In temperate deciduos forest soils, the top horizon of soil is a rich mixuture of humus (nutrient) and inorganic components but top soil of tropical rain forest is nutrient poor and shallow due to heavy rainfall.

(6) BIOSPHERE

All the living and non living components (Biotic + Abiotic) of the earth (biomes) combine together to constitute a large ecosystem called Biosphere. Biosphere is also called Ecosphere. The term ecosphere for biosphere was used by Cok.



(A) Lithosphere :-

The living components and non living components present on the earth surface consititutes the litho sphere.

(B) Hydrosphere :-

All living components and non living components present in water constitutes the hydrosphere.

(C) Atmosphere :-

All living components and non living components of air consitutes the atmosphere.

Note : Biosphere (space ship or earth) is a closed system for minerals and biosphere is an open system in regards with the energy.

Golden Key Points

- The formation of biome is mainly decided by two abiotic factor temperature and precipitation.
- Upper soil of temperate deciduous forest is more fertile than tropical rain forest.

BEGINNER'S BOX

NUTRIENT CYCLE, BIOME AND BIOSPHERE

1. Which is known as flora and fauna rich biome ?

(1) Temperate deciduous (2) Tropical rain forest

(3) Desert (4) Alpine

2. Which biome is specialised by thick covering of snow throughout the year ?

(1) Tropical rain forest (2) Tundra biome

(3) Taiga biome (4) Grassland

3. Savana biome is characterised by :

(1) Only grasses

(2) Grasses with scattered trees

(3) Broad leaf trees

(4) All of the above

4. Which is not a reservoir for phosphorous in phosphorous cycle ?

(1) Atmosphere (2) Lithosphere

(3) Hydrosphere (4) All of the above

03. ENVIRONMENTAL ISSUES (POLLUTION)

"Any undesirable change in physical, chemical or biological characteristic of air, water and land which is harmful to the man directly or indirectly through his animals, plants, industrial units or raw materials is called **pollution**".

Pollutants :- "Any material or act on the part of man, or nature which leads to pollution is called pollutants."

Some categories of pollutants:

- **Nonbiodegradable pollutants** :-

  Many of such pollutants are usually not degraded or degraded partially in environment. Such as aluminium packs, Mercury compounds, Iron, Compounds of phenols, Glass, D.D.T. benzene, BHC pesticides, etc.

  They are accumulated in the environment and cause pollution.

  These pollutants are harmful even in low concentration and harm increases with their increasing concentration.

  There are two methods by which we can stop the pollution caused by pollutants

  - Such type of substances should be banned by law.
  - Use their alternative substances.

- **Biodegradable pollutants –** If much of domestic sewage papers, woods, garbage, live stock wastes, etc. are easily degraded completely by microorganisms, it becomes useful. But if these materials enter the environment in such large quantities, that they can not be degraded completely then addition of these materials causes pollution in environment.

- **Primary pollutants –** These persist in the form in which they are added to the environment.

  e.g. DDT, CO etc.

- **Secondary pollutants –** These are formed by chemical reaction among primary pollutants

  e.g. Photochemical smog, London smog, PAN, O_3 etc.

  Process of formation of secondary pollutants is known as **synergism**. Secondary pollutants are more toxic than primary pollutants.

- **Quantitative pollutants –** These are the substances which occur in nature but become pollutant when their concentration reaches beyond a threshold value in the environment

  e.g. CO_2, Nitrogen Oxide etc.

- **Qualitative pollutants –** These are the substances which do not occur in the environment but are passed in through human activity.

  e.g. fungicides, herbicides, D.D.T., etc.

Other type of pollution :

- **Natural pollution –** Caused by natural sources like, CH_4 from paddy fields and cattle, marsh, forest fires etc.
- **Anthropogenic pollution –** Caused by human activities.
- **Negative pollution –** Loss of soil productivity. e.g., Overgrazing, Soil erosion.

  Removal or absence of desirable substances at right place which results in loss of soil productivity.
- **Positive pollution –** Presence or addition of undesirable substances at wrong place which results in reduction of soil fertility e.g. more use of fertilizer, Land filling by wastes.

(1) AIR POLLUTION

The air pollution is caused due to addition of unwanted substances or gases. The atmospheric pollution is mainly caused by the activities of man and concentrated to the inhabited and the industrial complexes in cities. There are two main categories of air pollutants

- **Gases :**

  The gaseous materials include various gases and vapours of volatile substances or the compound with a boiling point below 200^0C.
- **Particulate matter :**

  According to **central pollution control board (CPCB),** particulate size **2.5 micrometers** or less in diameter are responsible for causing the greatest harm to human health. These fine particulates can be inhaled deep into the lungs and can cause breathing and respiratory problems, irritation, inflammation and damage to the lungs and premature deaths.

(A) Major air pollutants and their effects :-

(i) Carbon monoxide (CO) –

Source – It is the main air pollutant released from smoke of automobile and burning of fossil fuels (Petrol, diesel, coal)

Effect – Carbon monoxide is highly toxic gas, it combines with haemoglobin and blocks the oxygen transport. Thus, it impairs respiration and it causes death due to asphyxiation when inhaled in large amount.

(ii) Unburnt Hydrocarbons : (3,4 Benzopyrine, Benzene)

Source – These are mainly released from automobiles and burning of fossil fuel (petrol, diesel, coal).

Effect – Hydrocarbons causes lung cancer.

(iii) Hydrocarbon : Methane (CH_4)

Methane is the most abundant unburnt hydrocarbon in atmosphere

Source – marshy area and paddy field.

Effect – Green house effect, Global warming.

(iv) Ethylene :

Source – Ethylene released in air during fruits ripening.

Effect – Premature falling of leaves & floral buds.

(v) Nitrogen oxide – (NO, NO_2) :

Source – Burning (combustion) of fossil fuel in automobiles.

Effect – These nitrogen oxide form photochemical smog in atmosphere and release ozone. Nitrogen oxide also responsible for acid rain. Entry of these nitrogen oxide causes respiratory trouble such as emphysema, bronchitis, swelling of lungs and lung cancer etc.

(vi) Sulphur oxide – (SO_2, SO_3)

Source – Main source of sulphur oxides are coal burning, smelters, oil refineries.

Effect – Lichen and mosses do not grow in SO_2 polluted areas. Lichen and mosses are indicator of SO_2 pollution. Sulphur oxides causes chlorophyll destruction. Taj Mahal also get affected.

(vii) Smoke – (SO_2, SO_3, NO_2, NO, CO, CO_2)

(B) Secondary Pollutants :-

(i) Smog (Smoke + Fog) –

Term given by Desvoeux. Smog/Smoke is measured by **Ringlmann method.**

Smog is of two types

(a) Los Angeles Smog or Photo Chemical smog or Oxidising smog –

It was first observed in Los Angeles. In this process smoke, fog, nitrogenoxide, hydrocarbons, oxygen, UV light and high temperature are essential. These components react with each other and form reddish brown smog (PAN + O_3 + Nitrogen oxides) or brown haze/brown air. Los angles smog is light induced smog.

Effect –

- Photochemical smog causes irritation in eyes and harms the lungs. Due to smog elastic substances (rubber/tyers) also affected.
- Ozone causes harm to mucous membrane.
- During smog peroxyacetyl nitrate (PAN) is formed. PAN stops or inhibits the photolysis of water in hill reaction of photosynthesis and affect or inhibit the photosystem-II. PAN also inhibit the chlorophyll formation in plants.

(b) London smog or sulphur smog or Classical smog or Reducing smog –

It was first observed in London. In this process coal, smoke, fog, sulphur oxide and low temperature are essential. These components react with each other and form vapour (fog) of H_2SO_4 which is known as London smog.

Effect –

- Due to inhalation of H_2SO_4 vapour with fog 4000 people died in London in 1952.

(ii) Acid rain –

This word was given by Robert August. **NO_2** and **SO_2** released from different sources in form of smoke and dissolved in atmospheric water vapour to form acid (H_2SO_4 + HNO_3). These acids fall on earth with rain water this is called acid rain.

(a) Wet deposition :- If acid falls on earth with rain, fog and smog, it is known as wet deposition.

(b) Dry depositon :- If acid settles on earth surface with solid dust particles with nitrate or sulphate, this is called dry deposition.

Note :

- The pH of acid rain is less than 5.6
- In acid rain the ratio of H_2SO_4 and HNO_3 is 7 : 3 (70% H_2SO_4 + 30% HNO_3)

Effects –

- Due to acid rain acidity of soil and water increases.
- Acid rain also causes damages historical monuments. e.g. Taj Mahal, Red Fort.
- **Stone leprosy** is caused due to acid rain because due to acid rain outer surface of metals, marbles, and stone destroyed.

(C) Control of Air Pollution :-

(i) Control of particulate matter – Two devices used to remove particulate air pollutants are **Arresters & Scrubbers**.

(a) Arresters :

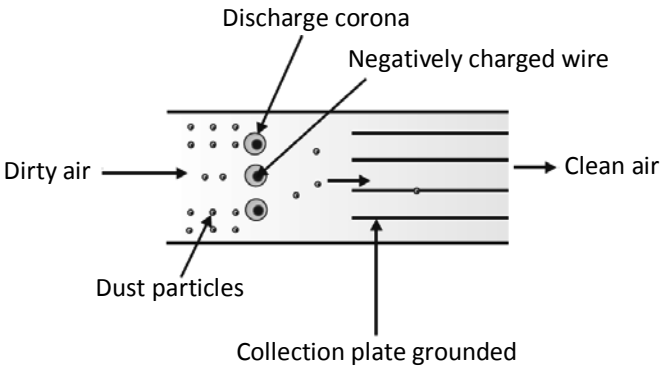
These are used to separate particulate matters from contaminated air.

Arresters are of different types :

- **Cyclonic separators and Trajectory separators :-** These are commonly used to separate out particulate matters from industrial emissions with minimum moisture content. These separators work on the principle of dust separation by centrifugal force.
- **Electrostatic precipitator :-** It is the most efficient device to remove fine particulate pollutants. Electrostatic precipitation device work on the principle of electrical charging of the dust particles and collecting it on a differently charged platform.

  There are several ways of removing **particulate** matter; the most widely used of which is the **electrostatic precipitator**, which can remove over 99 per cent particulate matter present in the exhaust from a thermal power plant.

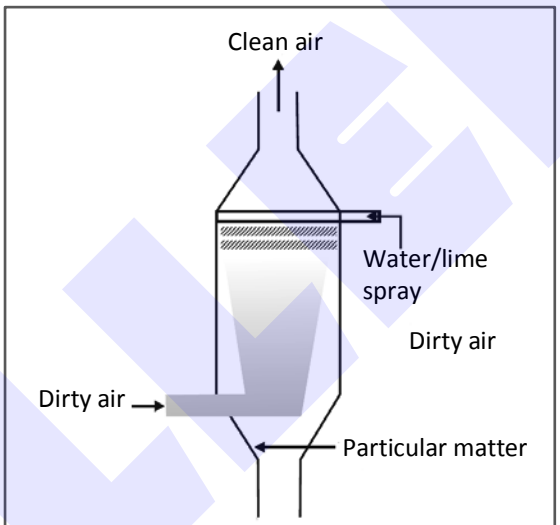
  It has electrode wires that are maintained at several thousand volts, which produce a corona that releases electrons. These electrons attach to dust particles giving them a net negative charge. The collecting plates attract the charged dust particles. The velocity of air between the plates must be low enough to allow the dust to fall.



Electrostatic precipitator
NCERT XII Page No. 271, Figure No. 16.1

(b) Scrubbers :

A scruber can remove gases like sulphurdioxide. In a scrubber, the exhaust is passed through a spray of water or lime.



Scrubber
NCERT XII Page No. 271, Figure No. 16.1

(ii) Control of Gaseous pollutants –

Combustion, absorption and adsorption technique are used to control gaseous pollutants.

(a) Combustion – In combustion process, oxidisable gaseous pollutants are completely burnt at a high temperature. Petrochemical, fertilizer, paints and varnish industries uses combustion control of gaseous pollutants.

(b) Absorption : Suitable solvents are used to absorbed toxic gaseous pollutants.

(c) Adsorption

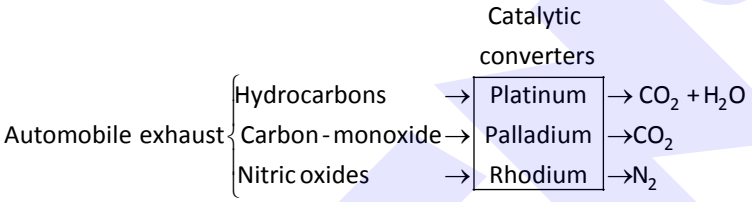
Catalytic converters :

Automobiles are a major cause for atmospheric pollution in the metro cities. Proper maintenance of automobiles along with use of lead free petrol or diesel can reduce the pollutants they emit.

Catalytic converters, having expensive metals namely **platinum, palladium** and **rhodium** as the catalysts, are fitted into automobiles for reducing emission of poisonous gases.

As the exhaust passes the catalytic converter, unburnt hydrocarbons are converted into CO_2 and water, and CO and nitric oxide are changed into CO_2 and nitrogen gas respectively.

Motor vehicles equipped with catalytic converter should use unleaded petrol because lead in the petrol inactivates the catalyst.



(iii) A Case study of Delhi –

(a) CNG (compressed natural gas) :

- In the 1990s, Delhi ranked fourth among the 41 most polluted cities of the world.
- All the buses of Delhi were converted to run on CNG by the end of 2002.
- CNG is the better than diesel because CNG burn most efficiently as compared to diesel or petrol in the automobiles and very little of it is left unburnt. CNG is cheaper than petrol or diesel.

(b) Euro norms :

The government of India through a new auto fuel policy has laid out a roadmap to cut down vehicular pollution in Indian cities. More stringent norms for fuels means steadily reducing the sulphur and aromatics content in petrol and diesel fuels.

Bharat stage Norms (Euro norms	Type of Vehicles	Cities	Date of Implementation	Amount of Sulphur in petrol	Amount of Sulphur in diesel	% of hydrocarbon content in fuels
Euro(III)	2,3,4, wheelers	All over India	October 2010	150 ppm	350 ppm	42%
Euro(IV)	4 wheelers	13 Mega cities	April 2010	50 ppm	50 ppm	35%
Euro(IV)	2,3,4 wheelers	All over India	April 2017	50 ppm	50 ppm	35%
Euro(VI)	2,3,4 wheelers	All over India	April 2020	10 ppm	10 ppm	35%

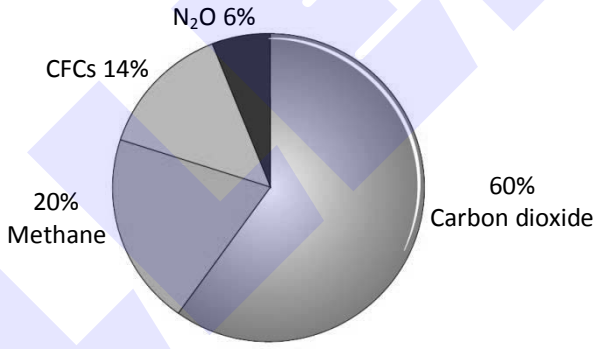
(D) Green House Effect :-

Definition :

- It is naturally occurring phenomenon responsible for heating of earth surface and atmosphere.
- In this phenomenon cover of CO_2 and other green house gases layer around the earth, allow the short wavelength incoming solar radiation to come in but does not allow the long wavelength of out going heat radiation from warm surface of earth and keep earth warm.
- Without greenhouse effect, the average temperature at surface of earth would have been a chilly –18°C rather than the present average of 15°C.

(i) Green House Gases :

- CO_2, CH_4, CFC, N_2O, O_3, watervapour released from industries and NOx released from agriculture which are responsible to increase green house effect.
- **Usually carbon dioxide is not considered as pollutant,** but its higher concentration forms a thick layer above the earth's surface, checks the radiation of the heat from the earth surface. Because of this, temperature of the earth's surface increases, this is called **global warming**.



Relative contribution of various greenhouse gases to total global warming
NCERT XII Page No. 281, Figure No. 16.7

(ii) Effect of increase in amount of Green house gases :

- It has been observed that in the recent past, the level of CO_2 in the atmosphere has increased from 280 ppm to 368 ppm in 1956 to 2002.
- Increase in the level of greenhouse gases has led to considerable heating of Earth leading to global warming. During the past century, the temperature of Earth has increased by 0.6°C, most of it during the last three decades.
- Even 2-3°C rise in temperature will lead to melting of glaciers and ice caps of polar region and consequently the floods in rivers, rise in sea level and changes in cycle of rain. Islands may be submerged in sea water.
- Sea level has been raised by 1 to 2 mm per year during 20^{th} century.

- Odd climate changes like El nino effect. Effect of El nino on India is flood, drought and Monsoon damage.
- **Carbondioxide fertilization effect –** Due to increased CO_2 concentration the rate of photosynthesis will increase (up to a few year). The response of the plants to elevated concentration of CO_2 is known as the CO_2 fertilisation effect.

(iii) Measures to control Global Warming :

- Cutting down use of fossil fuel
- Improving efficiency of energy usage.
- Reducing deforestation and planting trees.
- Slowing down human population growth.
- International initiatives like Kyoto protocol and Earth summit.

(E) Ozone Depletion :-

(i) Ozone layer :

- Ozone is present in less quantity in atmosphere. But at the height of **16 km to 25 km** on earth, concentration of ozone is maximum in stratosphere.
- At normal temperature and pressure thickness of ozone layer is **3 mm**. (But at poles thickness of ozone layer is **4 mm**).
- Thickness of ozone layer is measured in Dobson unit (1 Du = 1 ppb)

(ii) Depletion of Ozone layer :

- Ozone hole was first discovered in **1985** over Antarctica by **Nimbus-7** satelite.
- Ozone hole over Antarctica develops each year between late August and early October.

(iii) Ozone depleting substances (ODS) :

- Number of pollutants like CFCs (14% of total depletion), Nitrogen oxides (3.5%), CH_4 and halogens (chlorine) cause depletion of ozone layer Maximum. ODP (ozone depletion potential) is of CFCs due to release of chlorine.
- CFCs are released into atmosphere from refrigerators, air conditioners and jet planes.

(iv) Chemical process of ozone depletion (Chain reaction) :

$$CF_2Cl_2(g) + h\nu \longrightarrow \overset{\bullet}{Cl}(g) + \overset{\bullet}{C}F_2Cl(g)$$

$$\overset{\bullet}{Cl}(g) + O_3(g) \longrightarrow \overset{\bullet}{Cl}O(g) + O_2(g)$$

$$\overset{\bullet}{Cl}O(g) + O_3(g) \longrightarrow \overset{\bullet}{Cl}(g) + 2O_2(g)$$

↑

Active chlorine

Note :

- In this process of **one chlorine atom** convert one lakh O_3 molecules into O_2 by photodissociation.
- The life of CF_2Cl_2 **(CFC–12)** is 139 year while that for $CFCl_3$ **(CFC = 11)** is about 77 years.

(v) Effect of ozone depletion :

- Due to depletion of ozone layer harmful **UV** radiations are penetrating to the earth which causes **skin cancer (Melanoma)** and also acts as strong mutagens. UV radiation of wavelengths shorter than UV-B, are almost completely absorbed by Earth's atmosphere, given that the ozone layer is intact. But **UV-B** damages **DNA and mutation** may occur. It causes ageing of skin, damage to skin cells and various types of **skin cancers**.
- In human eye, cornea absorbs UV-B radiation, and a high dose of UV-B causes inflammation of cornea, called **snow-blindness, cataract, etc.** Such exposure may permanently damage the cornea. UV radiation causes a disease, **xeroderma pigmentosum.**

(vi) Measures to control ozone depletion :

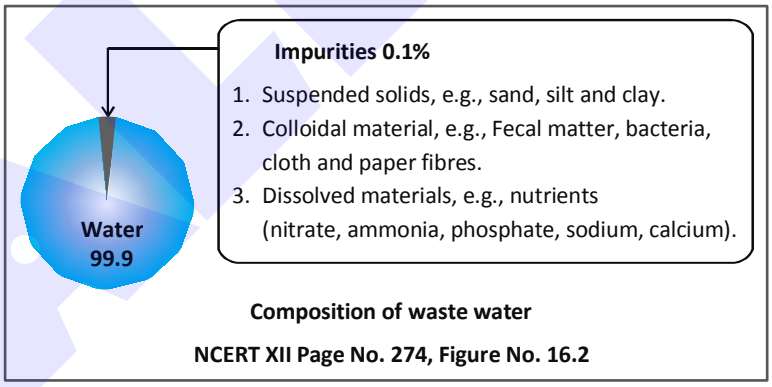
Montreal protocol was signed in 1987 to protect stratospheric ozone. It became effective in 1989.

(2) WATER POLLUTION

The water pollution is caused by the addition of organic and inorganic chemicals as well as the biological materials which change the physical and chemical properties of water. This harmful process is called **water pollution**.

The water pollution is caused by many sources such as sewage matter, industrial waste, agricultural waste, domestic waste, hot water of thermal plant and nuclear reactors etc.

Note : A mere 0.1 per cent impurities make domestic sewage unfit for human use (Figure).



Composition of waste water

NCERT XII Page No. 274, Figure No. 16.2

- Domestic sewage primarily contains biodegradable organic matter.
- Water hyacinth **(*Eichhornia crassipes*)**, the world's most problematic aquatic weed, also called **'Terror of Bengal'.**
- Unlike domestic sewage, waste water from industries like petroleum, paper manufacturing, metal extraction and processing, chemical manufacturing, etc., often contain toxic substance, notably heavy metals (defined as elements with density > 5 g/cm^3 such as mercury, cadmium, copper, lead, etc.) and a variety of organic compounds.

- Water having DO content below **8.0 mgL^{-1}** may be considered as contaminated and below **4.0 mgL^{-1}** heavily polluted.
- DO is measured by **oximeter**.

(A) Biochemical Oxygen Demand (BOD) :

The water pollution by organic wastes is measured in terms of Biochemical oxygen demand. It is the amount of dissolved oxygen **(DO = Dissolved Oxygen)** needed by bacteria in decomposing the organic wastes present in water.

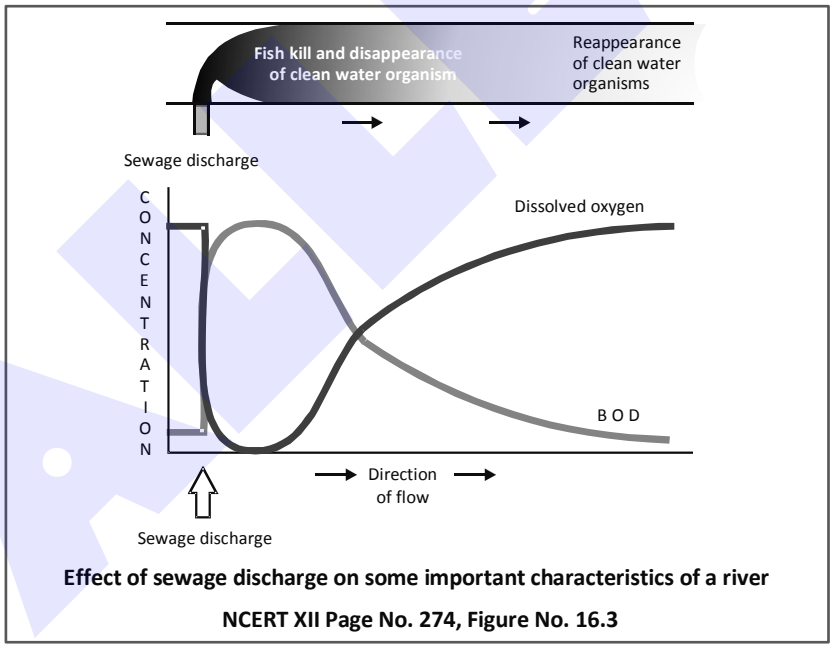
BOD increased = water polluted

BOD $\propto$ input of organic wastes

If B. O. D. is increased dissolved oxygen is decreased in water. Higher amount of organic waste increase the rates of decomposition in water. O_2 is rapidly consumed by microbes, thereby causing drop in DO content in water.

Note :

- ***Daphnia*** is the indicator of BOD



Effect of sewage discharge on some important characteristics of a river

NCERT XII Page No. 274, Figure No. 16.3

Note : There is sharp decline in dissolved oxygen downstream from the point of discharge.

(B) Chemical Oxygen Demand (COD) :

COD is the oxygen required by chemicals like $K_2Cr_2O_7$ for oxidation of total organic matter (biodegradable + non biodegradable) in water.

Note : COD value is always higher than BOD value.

(C) Biological magnification/Bio magnification :

Water ⟶ Phytoplankton ⟶ ZP ⟶ Small fish ⟶ Large fish → Fish eating birds

(DDT = 0.003 ppb) (0.003 ppm) (0.04 ppm) (0.5 ppm) (2 ppm) (25 ppm)

The non-biodegradable pollutant like Al, Hg, Fe, DDT, pesticides, phenolic compound ABS (Alkyl benzene sulphonate) are not decomposed by micro-organisms.

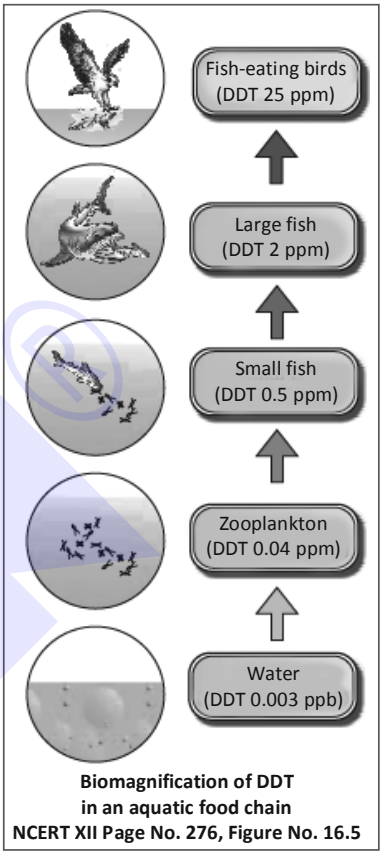
They get accumulated in tissue in increasing concentration along the food chain is called biological magnification. **The highest concentration occurs in top consumer.**

Example :

- The concentration of DDT is increased at successive trophic levels; say if it starts at 0.003 ppb (ppb = parts per billion) in water, it can ultimately can reach 25 ppm (ppm = part per million) in fish-eating birds, through biomagnification.

  Note : High concentration of DDT distrub calcium metabolism in birds, which causes thinning of egg shell and their permature breaking, eventually causing decline in bird populations.

- **Minamata disease** is cause in humans in Japan by biomagnification of mercury (Hg)



Biomagnification of DDT in an aquatic food chain
NCERT XII Page No. 276, Figure No. 16.5

Note : Silent spring – Book written by Rachel Carson based on environmental harm caused by use of pesticides.

(D) Eutrophication :-

The process of nutrient enrichment of water and consequent loss of species diversity (or death of aquatic animals) is referred to as eutrophication and lake is known as eutrophic lake. In this process presence of nutrients in lake stimulates growth of algae (algal bloom) increase organic loading and bring about reduction in the oxygen content of water causing death of aquatic animals.

(i) Effect of eutrophication :

- Eutrophication is the natural aging of a lake by biological enrichment of its water. Natural aging of a lake may span thousands of years and lake finally converted into land due to deposition of silt. Pollutants from man's activities like effluents from the industries and homes can radically accelerate the aging process, this phenomenon is called **accelerated eutrophication or cultural eutophication.**
- During eutrophication due to organic matter lake become **shallow** and **warmer**. Due to warming of lake water, growth of cold water organisms stop and growth of warm water organisms increases.
- B.O.D. of Eutrophic lake is very high.

Types of Lakes :

- **Eutrophic lake –** They are shallow water lakes which contain **high amount of organic materials** and nutrients. They have little O_2 because decomposers rapidly use it up. Chironomous larva are commonly present in it.
  e.g. Dal lake of Kashmir
- **Oligotrophic lakes –** These are deep lakes which have **less amount of organic materials and nutrient**.

(ii) **Sources :** man made pollutant causing eutrophication.

(a) **House hold detergents** – Phosphate, Nitrate, Sulphate

(b) **Industrial waste** – Paper industry waste, dairy industry waste, distillery industry waste

(c) **Chemical fertilizer** – Increasing amount of chemical fertilizer can do to aquatic ecosystem vis-à-vis eutrophication.

(d) **Sewage**

- A major component of municipal waste water is human excreta also called sewage.
- It contains large amounts of organic matter and microbes, many of which are pathogenic.
- This sewage cannot be discharged into natural water bodies directly therefore sewage is treated in STP's before disposal to make it less polluting.

- **Sewage treatment :**
  - **Step-1 : Primary treatment :**
    These treatment steps basically involve physical removal of particles-large and small-from the sewage through filtration and sedimentation. These are removed in stages; initially, floating debris is removed by sequential filtration. Then the grit (soil and small pebbles) are removed by sedimentation. All solids that settle, form the **primary sludge**, and the supernatant forms the effluent or primary effluent. The primary effluent from the **primary settling tank** is taken for secondary treatment.
  - **Step-2 : Secondary treatment or biological treatment :**
    The primary effluent is passed into large aeration tanks where it is constantly agitated (mix) mechanically and air is pumped into it. This allows vigorous growth of useful aerobic microbes into **flocs** (masses of bacteria associated with fungal filaments to form mesh like structures). While growing, these microbes consume the major part of the organic matter in the primary effluent.

This significantly reduces the **BOD** of the effluent. BOD refers to the amount of the oxygen that would be consumed if all the organic matter in one liter of water were oxidised by bacteria. The sewage water is treated till the BOD is reduced. The BOD test measures the rate of uptake of oxygen by micro-organisms in a sample of water and thus, indirectly, **BOD is a measure of the organic matter present in the water.** The greater the BOD of waste water, more is its polluting potential.

Once the BOD of sewage or waste water is reduced significantly, the effluent or secondary effluent is then passed into a **secondary settling tank** where the bacterial 'flocs' are allowed to sediment. This sediment is called **activated sludge**. The sludge is pumped into large tanks called **anaerobic sludge digesters**. Here, other kinds of bacteria, which grow anaerobically, digest the bacteria and the fungi in the sludge. During this digestion, bacteria produce a mixture of gases such as methane, hydrogen sulphide and carbon dioxide. These gases form biogas and can be used as source of energy as it is inflammable.

The effluent from the secondary treatment plant is generally released into natural water bodies like rivers and streams.

The **Ministry of Environment and Forests** has initiated **Ganga Action Plan** and **Yamuna Action Plan** to save these major rivers of our country from pollution. Under these plans, it is proposed to build a large number of sewage treatment plants so that only treated sewage may be discharged in the rivers.

- **Step-3 : Tertiary treatment/Physico-chemical treatment :** is used to make potable water.

(E) Water pollution indicator :

Daphnia, trout fishes and larva of stone fly are the fresh water indicators and Tubifex (an annelid), chironomous larva, E.coli, Sewage fungus, Sludge worms, blood worms are the indicator of polluted water.

(F) Thermal waste water :

Heated (thermal) wastewaters flowing out of electricity-generating units, e.g., thermal power plants, constitute another important category of pollutants. Thermal wastewater eliminates or reduces the number of organisms sensitive to high temperature, and may enhance the growth of plants and fish, which live in high temperature in cold areas but, only after causing damage to the indigenous flora and fauna.

(G) A case Study of Integrated Waste Water Treatment :-

- Wastewater including sewage can be treated in an integrated manner, by utilising a mix of artificial and natural processes. An example of such an initiative is the town of **Arcata**, situated along the northern coast of California. Collaborating with biologists from the **Humboldt State University**, the townspeople created an integrated waste water treatment process within a natural system.

The cleaning occurs in two stages –

(a) Step 1 : The conventional sedimentation, filtering and chlorine treatments are given. After this stage, lots of dangerous pollutants like **dissolved heavy metals** still remain. To combat this, an innovative approach was taken.

(b) Step 2 : Biologists developed a series of **six connected marshes** over 60 hectares of marshland. Appropriate plants, algae, fungi and bacteria were seeded into this area, which neutralise, absorb and assimilate the pollutants. Hence, as the water flows through the marshes, it gets purified naturally.

- The marshes also constitute a sanctuary, with a high level of biodiversity in the form of fishes, animals and birds that now reside there.
- A citizens group called Friends of the Arcata Marsh **(FOAM)** are responsible for the upkeep and safeguarding of this wonderful project.

(H) Sustainable systems for handling human excreta :

- Ecological sanitation is a sustainable system for handling human excreta, using **dry composting toilets**.
- This is a practical, hygienic, efficient and cost-effective solution to human waste disposal.
- The key point to note here is that with this composting method, human excreta can be recycled into a resource (as natural fertiliser), which reduces the need for chemical fertilisers. There are working **'EcoSan' toilets** in many areas of **Kerala and Sri Lanka**.

(3) SOUND POLLUTION

- Noise is undesired high level of sound.
- Intensity of sound is measured in bel or decibel. [1 bel = 10 dB]
- Normally at 25 dB atmosphere is peaceful but sound intensity above 80 dB is called noise pollution.
- Causes of noise pollution may include – Motor vehicles, Industries, Mills, Loud speakers, Construction sites, Jet planes etc.

Note :

- In India, the Air (Prevention and Control of Pollution) Act came into force in **1981**, but was amended in **1987** to include noise as an air pollutant.
- Noise causes psychological and physiological disorders in humans. A brief exposure to extremely high sound level, 150 dB or more generated by take off of a jet plane or rocket, may damage ear drums thus permanently impairing hearing ability.
- Even chronic exposure to a relatively lower noise level of cities may permanently damage hearing abilities of humans. Noise also causes sleeplessness, increased heart beating, altered breathing pattern, thus considerably stressing humans.
- Reduction of noise in our industries can be affected by use of sound absorbent material or by muffling noise.
- **Green muflur scheme** – Tree such as **neem** and **ashoka** absorb sound to a great extent, along road side.

(4) SOLID WASTES

Solid wastes refer to everything that goes out in trash. Municipal solid wastes are wastes from homes, offices, stores, schools, hospitals, etc., that are collected and disposed by the municipality. The municipal solid wastes generally comprise paper, food wastes, plastics, glass, metals, ruber, leather, textile, etc. Burning reduces the volume of the wastes, although it is generally not burnt to completion and open dumps often serve as the breeding ground for rats and flies. **Sanitary landfills** were adopted as the substitute for open-burning dumps. In a sanitary landfill, wastes are dumped in a depression or trench after compaction, and covered wth **dirt everyday**.

(A) Control of solid waste :-

(i) **House hold waste** $\rightarrow$ Landfills and incineration.

(ii) **Incineration –** Solid wastes burning in presence of oxygen. The use of incinerators is crucial to disposal of hospital waste

(iii) **Pyrolysis –** Solid wastes burning (combution) in the absence of oxygen.

(iv) **Electronic waste –** is also called e-wastes. Irreparable computers and other electric goods are known as electronic wastes (e-wastes). E-wastes are buried in landfills or incinerated. Eventually recycling is the only solution for the treatment of e-wastes.

Note : Landfills are also not really much of a solution since the amount of garbage generation specially in the metros has increased so much that these sites are getting filled too. Also there is danger of seepage of chemicals, etc, from these landfills polluting the underground water resources.

(B) Case Study of Remedy for Plastic Waste :-

- **Ahmed Khan**, aged 57 years old and plastic sac manufacturer has been producing plastic sacks for 20 years. About 8 years ago, he realised that plastic waste was a real problem. **Polyblend**, a fine powder of recycled modified plastic, was developed then by his company. This mixture is mixed with the **bitumen** that is used to lay roads.
- In collaboration with R.V.College of Engineering and the Bangalore City Corporation, Ahmed Khan proved that blends of Polyblend and bitumen, when used to lay roads, enhanced the bitumen's water repellant properties, and helped to increase road life by a factor three. The raw material for creating Polyblend is any plastic film waste.

(5) RADIOACTIVE POLLUTION

- Initially, nuclear energy was hailed as a non-polluting way for generating electricity.
- Later on, it was realised that the use of nuclear energy has two very serious inherent problems.
  - The first is accidental leakage of radiation occurred in the **Three Mile Island** and **Chernobyl.**
  - Second is safe disposal of radioactive wastes. It has been recommended that storage of nuclear waste, after sufficient pre-treatment, should be done in suitably shielded containers buried within the rocks, about **500 m deep** below the earth's surface.

(6) OTHER IMPORTANT INFORMATION

(A) **MIC [Methyl Isocyanate]** was released in Bhopal gas tragedy on **3rd December 1984**. Which is used in the production of "Sevin" insecticide in Union Carbide factory.

(B) Tetraethyl lead $[Pb(C_2H_5)_4]$ and tetramethyl lead $[Pb(CH_3)_4]$ are fuel additives which releases Pb during combustion.

- The disease produced by use of lead polluted water is called as **Plumbism**.
- Lead causes nervousness anaemia in human beings. It also damages kidney.
- Lead concentration in blood is considered alarming if it is 10 μg/ 100 ml.

(C) **Pneumoconiosis** : Common dust disease

- Disease due to cotton dust in textile workers is – **Lung fibrosis or Byssinosis**
- Disease due to coal dust – **Anthracosis**
- Disease due to asbestos dust – **Asbestosis**
- In stone grinders disease due to silica dust – **Silicosis**
- In Iron mill disease due to iron dust – **Siderosis**

(D) **Blue Baby disease** :- This disease is caused by the high amount of nitrate in water. It is also known as **Methaemoglobinaemia** or **Cyanosis**.

(E) **Hypertension and Uremia** – Caused by Copper

(F) **Arsenic** :

It causes black-foot disease in humans (Endemic to Taiwan) and poisoning in fodder plants which are eaten by live stock and causes their death.

(G) **Cadmium :**

causes anaemia, hypertension, damage to liver and kidneys. In Japan it caused bone softening or skeleton deformity called **Itai-Itai disease or Ouch-Ouch**

(H) **Fluorides** :-

The higher concentration of fluorides causes chlorosis or necrosis in tips and margin of leaf (leaf lamina). The compounds of fluorine reach in the animals through the fodder and causes abnormal calcification of teeth, this is called **Fluorosis.**

Note : The experts hold that the maximum level of fluoride which the human body can tolerate is **1.5 parts per million[ppm].** When ingested in excess over a long period of time causes "Fluorosis".

(I) **ELNino effect** -

It is the process in which water of Pacific ocean get warm, in this process warm water current flows to equador & peru in between 5 to 8 year at christmas time. **Effect of ELNino is flood, drought** and **monsoon damage in India.** On the other hand when cold water comes in effect in pacific ocean it is called **La-Nina** effect.

(J) Major pollutant in Jet plane emission is CFC.

(K) **Third pollution or land scape pollution :-** To make Fertile-land barren by dumping wastes e.g., ash, industrial waste

(L) **Flu gas –** Gas which is released from chimnies.

(M) **Plume –** Smoke which is released from chimnies.

(N) **Phytotrons –** A such type of house where plants are grown in controlled environment.

(O) **Hydrocarbon –** Are also known as volatile organic carbons (VOC).

(P) Ganga Action plan for controlling pollution in ganga (1985) included city :

(i) Kolkata (ii) Kanpur.

(Q) At 50 ppm, CO converts 7.5% of haemoglobin in to carboxy haemoglobin with in 8 hours.

(R) Maximum green house gas released by – China.

(S) Cotton dust is an important pollutant in Ahmedabad.

(T) Environment law for controlling pollution :

(i) The National Environment (Protection) Act (NEPA) 1986 :-

This act clearly brings the protection of water and soil quality, and the control environmental pollutants.

(ii) The insecticide Act, 1968 :-

This act deals with the regulation of import, manufacture, sale, transport, distribution and use of insecticides with a view of preventing risk to human health and other organisms.

(iii) The water (Prevention and control of pollution) Act, 1974 :-

This act deals with the preservation of water quality and the control of water pollution with a concern for the detrimental effects of water pollutants on human health.

(iv) The air (Prevention and control of Pollution) Act, 1981 :-

This act deals with the preservation of air quality and the control of air pollution with a concern for the detrimental effects of air pollutants on human health and also on the biological world. Noise was added as air pollutant by an amendment in 1987.

Important Informations :

- Conference on human environment in 1972 held at Stockholm.
- Recognising the deleterious affects of ozone depletion, an international treaty, known as the **Montreal protocol** was signed in 1987 Montreal (canada) 27 industrialised countries signed the Montreal protocol to protect **stratospheric ozone**. It's effective in 1989. More than 175 countries have signed the montreal protocol.
- UNCED (United Nations Conference on Environment and Development) Earth Summit held at Rio-de-Jenerio (Brazil) in 1992 for reducing green house gases & **biodiversity conservation** and make Agenda-21.
- Kyoto protocol conference held in **Kyoto** (Japan) for **climate change** (1997). This protocol requires countries to take appropriate measures to reduce their overall green house gas emisson to a level at 5 percent below the 1990 level by the commitment period 2008-2012.
- **World summit** on sustainable development **(2002)** was held in **Johannesburg (S. Africa).**

(U) Important dates about environmental issues :

* COP = Conference of the parties
* UNCED = June 1992 (Adopted)
  March 1994 (Effective)
* Conducted by – UNFCCC (United Nations Framework Convention on Climate Change)

	Meeting	Date	Venue
1	COP-1	1995	Berlin, Germany
2	**COP-3**	1997	Kyoto, Japan (Adopted the Kyoto Protocol)
3	COP-8	2002	New Delhi, India
4	COP-11	2005	Montreal, Canada (Implemented the Kyoto Protocol)
5	COP-17	2011	Durbon/South Africa
6	**COP-18**	2012	Doha/Qatar (Amendment of Kyoto Protocol, Extended upto 2020)
7	COP-19	2013	Warsaw/Poland
8	COP-20	2014	Lima/Peru
9	**COP-21**	2015	Paris/France
10	COP-22	2016	Marrakesh, Morocco
11	COP-23	2017	Bonn, Germany
12	COP-24	2018	Katowice, Poland
13	COP-25	2019	Madrid, Spain
14	COP-26	2021	Glasgow, Scotland
15	**COP-27**	2022	Sharm-El-Sheikh, Egypt

(7) EFFECT OF AGRO CHEMICALS AND IMPROPER RESOURCE UTILISATION

In the wake of green revolution use of agro chemicals like inorganic fertilizers and pesticides, weedicides, fungicides etc. has increased manifold for enhancing crop production. It harms the non targeted organisms important component of the soil ecosystem.

- The action of pollutants and improper resource utilization like unrestricted grazing, deforestation and poor irrigation practies increase **soil erosion** and **desertification.**
- Irrigation without proper drainage of water leads to **water logging** which results in increase in **soil salinity.**

(8) CASE STUDY OF ORGANIC FARMING

- Integrated organic farming is a cyclical, **zero-waste procedure**, where waste products from one process are cycled in as nutrients for other processes. This allows the maximum utilisation of resource and increases the efficiency of production.
- **Ramesh Chandra Dagar**, a farmer in **Sonipat, Haryana**, is doing just this. He includes bee-keeping, dairy management, water harvesting, compositing and agriculture in a chain of processes, which support each other and allow an extremely economical and sustainable venture.

- There is no need to use chemical fertilisers for crops, as cattle excreta (dung) are used as manure.
- Crop waste is used to create compost, which can be used as a natural fertiliser or can be used to generate natural gas for satisfying the energy needs of the farm.
- Enthusiastic about spreading information and help on the practice of integrated organic farming. Dagar has created the **Haryana Kisan Walfare Club**, with a current membership of 5000 farmers.

Golden Key Points

- Automobiles are the major cause of pollution in metro cities.
- Composition of acid rain **– 70% (H_2SO_4)** and **30% (HNO_3)** and **pH < 5.6**
- Green house effect is a natural phenomenon responsible for heating of atomosphere and earth's surface.
- Most efficient method for removing particulate matter from exhaust is **Electrostatic precipitator (ESP)**
- **According to Euro norms-IV Sulphur content should be reduced to 50 ppm in Petrol and Diesel.**
- Good ozone (responsible UV absorption) is present in stratosphere whereas bad ozone (Pollutant) is present in Troposphere.
- Maximum concentration of non-biodegradable pollutants occur in top consumers **(Biological magnification)**
- Nutrient enrichment leading to **natural ageing** of lake is called **Eutrophication.**
- Increases pollutants due to human activities can accelerate ageing of lake called accelerated or cultural eutrophication.
- Treatment of waste water is done by the heterotrophic microbes, naturally present in sewage.
- **BOD $\propto$ organic matter $\propto$ pollution $\propto \frac{1}{DO}$**
- National forest policy **(1988)** in India recommended **33%** of forest cover for plains and 67% of forest cover for hills.
- Ecological sanitation is sustainable system for handling human excreta by dry composting.
- Polyblend is a fine powder of recycled modified plastic and raw material for creating it is any plastic film waste.
- For two wheelers, Bharat stage IV is applied all over India since 1st April, 2017.

BEGINNER'S BOX — ENVIRONMENTAL ISSUES (POLLUTIONS)

1. Photo-chemical smog is :

(1) $H_2SO_4 + HNO_3$ (2) Vapours of H_2SO_4 (3) PAN + O_3 + NO_X (4) PAN + H_2SO_4

2. Due to green house effect, present average temperature of earth is :

(1) –18°C (2) 15°C (3) 0.6°C (4) 25°C

3. Thickness of ozone layer is measured is :

(1) Deci-bel (2) mg/L (3) PM (4) Dobson unit

4. Which of the following is also called "Terror of Bengal" –

(1) Water hyacinth (2) Water lilly (3) African catfish (4) E.Coli

5. Gas released during Bhopal gas tragedy was :

(1) Ozone (2) Methane

(3) Methyl isocyante (4) Alkyl benzene sulphonate

04. BIODIVERSITY AND CONSERVATION

(1) RESOURCES

(A) Natural Resources :

The materials or any component, that can be utilised by man and are necessary for welfare of life, which is available in the natural environment in Atmosphere, Hydrosphere, Lithosphere is called natural resources.

e.g. O_2, Land, Soil, Water, Forest, Animals, Soil, microorganism

Classification of natural resources

In exhaustible
- Solar Energy
- Wind Energy
- Rainfall
- Tidal energy
- Hydro power

Exhaustible

Renewable
- Water
- Soil
- Natural vegetation
- Wildlife
- Aquatic animals
- Most of biotic resources

Non-renewable
- Fossil fuels
- Biological species
- Minerals/Metals
- Nuclear energy

Note :- Nuclear energy is non-renewable and provides unlimited energy.

(i) Hydrosphere or Water Resources :

The total volume of water in the hydrosphere is 1.4 billion cubic kilometres [Km^3], about **97.5%** is the **ocean water**, unsuitable for human use. Only **2.5%** is available as **fresh water.** About **1.97%** is stored in **ice-caps** (Polar ice) and glaciers and 0.5% is ground water and soil moisture (0.01%). The rest [about 0.03 percent] is distributed in lakes swamps, rivers and streams.

(ii) Land Resources :

At the beginning of 20th century, about **30%** of land in India was covered with forest but the end of the 20th century, the forest cover reduced to **21.54%.** Out of 21.54%, only **12%** area covered by dense forest.

- Per capita forest area available in India is = **0.06** hec.
- Per capita forest area available in world is = **0.64** hec.
- **National Forest Policy (1988)** of India has recommended **33 per cent** forest cover for the plains and **67 per cent** for the hills.

(B) Deforestation :

- **Shifting Cultivation or Jhum Cultivation :**

  Slash and burn agriculture, commonly called as **Jhum cultivation** in the north-eastern states of India, has also contributed to deforestation.

  It is a major cause of deforestation. Many tribal communities practise slash and burn agriculture in tropical and subtropical regions of Asia, Africa and Oceania. This consists of cutting down trees and setting them on fire and raising crops on the resulting ash called "Jhuming" in north eastern India.

- **Effect of deforestation –** One of the major effects is enhanced carbon dioxide concentration in the atmosphere because trees that could hold a lot of carbon in their biomass are lost with deforestation. Deforestation also causes loss of biodiversity due to habitat destruction, disturbs hydrologic cycle, causes soil erosion, and may lead to desertification in extreme cases.

(C) Forest conservation :

It is conducted by two methods

(i) Protection or conservation forestry : By making national park and Bio-sphere Reserve.

(ii) Production or commercial forestry : It is of two types

(a) Social forestry - To grow the trees and shrubs on unused farmland, road sides, Rail sides, community land etc.

(b) Agro-forestry : Woody species are grown in combination with herbaceous crops either at the same time or in time sequence.

Silent Valley :-

It is tropical evergreen forest in Kerela (Palghat) declared as National Reserve Forest. It is called silent valley because there is no noise in the forest during night, even that of cicadas, as they are not found there. **It is related to conservation of forest.**

(D) Case study of People's Participation in Conservation of Forests :

- People's participation has a long history in India. In **1731**, the king of **Jodhpur in Rajasthan** asked one of his ministers to arrange wood for constructing a new palace. The minister and workers went to a forest near a village, inhabited by Bishnois, to cut down trees. The Bishnoi community is known for its peaceful co-existence with nature. The effort to cut down trees by the kings was thwarted by the Bishnois. A Bishnoi woman **Amrita Devi** showed exemplary courage by hugging a tree and daring king's men to cut her first before cutting the tree. The tree matiered much more the her than her own life. Sadly, the king's men did not heed to her pleas, and cut down the tree along with Amrita Devi. Her three daughters and hundreds of other Bishnois followed her, and thus lost their lives saving trees.
- The Government of India has recently instituted the **Amrita Devi Bishnoi Wildlife Protection Award** for individuals or communities from rural areas that has shown extraordinary courage and dedication in protecting wildlife.
- You may have heard of the **Chipko Movement** of Garhwal Himalayas. In **1974**, local women showed enormous bravery in protecting trees from the axe of contractors by hugging them.
- **Chipko Movement** was born in March-1974 at Gopeshwar in Chamoli district. The movement had two leaders- Sundarlal Bahuguna of Silyara in Tehri and Chandi Prasad Bhatt of Gopeshwar. It was for plant conservation.
- Realising the significance of participation by local communities, the Government of India **1980s** has introduced the concept of **Joint Forest Management (JFM)** so as to work closely with the **local communities** for protecting and managing get benefit of various forest products (e.g., fruits, gum, rubber, medicine etc.) and thus the forest can be conserved in a sustainable manner.

(E) Threatened Species Concept :

In India the **Wildlife (Protection) Act, 1972** provides four schedules categorising the fauna of India based on their conservation status.

The International Union for Conservation of Nature and Natural Resources **(IUCN)**, having its head quarters at **Morgis in Switzerland and maintains a Red Data Book** providing a record of animals and plants which are known to be in danger.

Threatened (T) : The term is used in context with conservation of the species which are in any one of the folllowing category

Some important examples of threatened species in india

	Category	Plants	Animals
(1)	Critically endangered	*Barberis nilghiriensis*	Pygmyhog
(2)	Endangered	*Bentinckia nicobarica*	Red panda
(3)	Vulnerable	*Cupressus cashmeriana*	Black buck

Note : (1) *Rauwolfia serpentiana* (medicinal plant) is endangered .

(2) Hornbill and Indian Aconite are also endangered.

(2) METHOD OF BIODIVERSITY CONSERVATION

(A) In-Situ conservation – Conservation in natural habitat.

(i) Hot Spot :

Norman Myers developed the hot spot concept in 1988. This is a mega diversity zone. Where large number of species are found. It is an area of the richest and the most threatened reservoirs of plant and animal life on the earth. Initially 25 biodiversity hot spots were identified in world, now **number of biodiversity hot spot in the world are 34 out of these 3 hotspots are found in India i.e. Western Ghats, Sri Lanka, Indo-Burma and the Himalayas.**

Note :

The key criteria for determining a hot spot are :

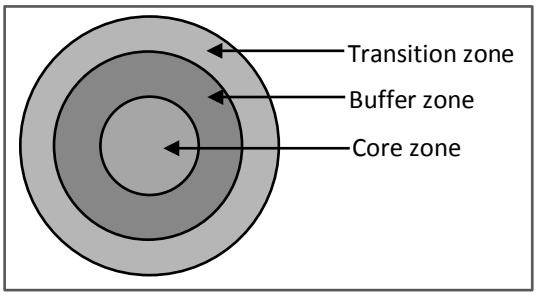
- High level of species richness
- High degree of endemism (that is, species confined to that region and not found anywhere else)
- High degree of threat which is measured in terms of habitat loss (It means hot spots are regions of accelerated habitat loss).
- Although all the biodiversity hotspots put together cover less than 2 percent (1.4%) of the earth's land area, the number of species they collectively harbour is extremely high and strict protection of these hotspots could reduce the ongoing mass extinctions by almost 30 per cent.

(ii) Biosphere Reserves

It is a specified protected area in which multiple use of the land is permited.

There are 3 zones of Biosphere Reserve.

1. **Core Zone :** It lies at the centre where no human activity is allowed.
2. **The Buffer zone :** Where limited human activity is allowed.
3. **Manipulating zone or Transition zone :** Where a large number of human activites would go on.



Note : 408 Biosphere reserves are located in 94 countries out of which 14 sites are present in India. In India following **14 sites** have been identified as potential biosphere reserves together with their locations:

Biosphere Reserve	State(s)
1. Nanda Devi	Uttarakhand
2. Nokrek	Meghalaya
3. Manas	Assam
4. Dibru Saikhowa	Assam
5. Dehang Debang	Arunachal Pradesh
6. Sunderbans	West Bengal
7. Gulf of Mannar	Tamil Nadu
8. Nilgiri	Kerala, Karnataka and Tamil Nadu
9. Great Nicobar	Andaman & Nicobar
10. Simlipal	Odisha
11. Khanchendzonga	Sikkim
12. Pachmarhi	Madhya Pradesh
13. Agasthyamalai	Kerala, Tamil Nadu
14. Achankamar	Madhya pradesh, Chattisgarh

(iii) National park

Name & Location of National Parks of India	Important Animals found
1. Kaziranga National Park District Sibsagar(Assam)	**Rhinoceros**
2. Sundarbans (Tiger Reserve) 24-Pargana (West Bengal)	**Tiger**
3. Hazaribagh National Park Hazaribagh Jharkhand	**Tiger**
4. Corbett National Park District Nainital (Uttarakhand)	**Tiger**
5. Gir National Park District Junagarh (Gujarat)	**Asiatic lion**
6. Kanha National Park Mandla and Balaghat (M.P.)	**Tiger, panther, chital, chinkara, four horned deer**
7. Tandoba National Park Chandrapur (Maharashtra)	**Tiger**
8. Bandipur National Park District Mysore (Karnataka)	**Elephant, tiger, leopard**
9. Desert National Park Jaisalmer, Barmer (Rajasthan)	**Great Indian Bustard, Black buck, Chinkara.**
10. Nanda Devi –Uttarakhand (Chamoli District)	**White Tiger**

(iv) Some Important Sancutaries of India

Name & Location	Important Animals
1. Keoladeo Ghana Bird Sanctuary Bharatpur (Rajasthan) Famous for birds	**Siberian crane**
2. Annamalai Sanctuary, Coimbatore (Tamil Nadu)	**Tiger, Elephant**
3. Dachigam Sanctuary Srinagar (Jammu & Kashmir)	**Hangul or Kashmir stag, Musk deer**
4. Nagarjuna Sagar Sanctuary, Guntur, Kamool and Nalgonda (Andhra Pradesh)	**Tiger, Panther**
5. Periyar Sanctuary (Kerala)	**Elephants**, **Leopard**, **Hornbill**
6. Chilka Lake Bird Sanctuary, Odisha (Largest brackish water lagoon in Asia)	**Water fowls, Ducks, Cranes**
7. Manas Wildlife Sanctuary, Assam	**Tiger, Panther**

(v) Sacred groves

- In many cultures, tracts of forest were set aside, and all the trees and wildlife within were venerated and given total protection.
- Such sacred groves are found in Khasi and Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghat regions of Karnataka and Maharashtra and the Sarguja, Chanda and Bastar areas of Madhya Pradesh.
- In Meghalaya, the **sacred groves** are the last refuges for a large number of rare and threatened plants.

Note :

- In India, ecologically unique and biodiversity-rich regions are legally protected as biosphere reserves, national parks and sanctuaries.
- India now has **14** biosphere reserves, **90** national parks and **448** wildlife sanctuaries. India has also a history of religious and cultural traditions that emphasised protection of nature.
- **Some Special Animals –**
  - **Asiatic wild ass – (Endangered) –** Found in runn of Kutch and Pakistan
  - **Red Panda – (Endangered) –** Found in Khanchendzonga (Sikkim)
  - **Hangul–Kashmir Stag (Critically Endangered)–**Found in Dachigam (Sri-Nagar – Jammu & Kashmir)
  - **Siberian Crane (Critically Endangered) –** Found in Keoladeo (Ghana) National Park Bharatpur (Rajasthan).

- **The Great Indian Bustard (Critically Endangered)** is a huge ground bird with a long neck and long bare legs. It is an inhabitant of the semi-arid areas of Rajasthan, Gujarat and Maharashtra.Hunting for its flesh has reduced its population to over 800. It is a Critically endangered bird.

- **The world's first National Park (America) –** Yellow stone National Park
- **India's first National Park –** Jim Corbett National Park – Nainital (Uttarakhand)
- **Smallest tiger reserve in India –** Bor Tiger Reserve Maharashtra.
- **Largest Tiger reserve in India –** Nagarjuna Sagar Srisailum Tiger Reserve - Guntoor - Andhra Pradesh.
- **Nandan-Kanan zoo (Bhubaneshwar - Odisha) is known for -** White tiger.
- Sunderbans [W.Bengal] is also famous for Royal Bengal tigers.

(B) Ex-Situ conservation – Conservation outside Natural habitat.

- The protection of wild life in zoos and botanical gardens. Other e.g. of Ex-situ conservation are **gene banks, germ plasm bank, seed bank.**
- In this approach, threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care.
- **Zoological parks**, **botanical gardens** and **wildlife safari parks** serve this purpose.
- There are many animals that have become extinct in the wild but continue to be maintained in zoological parks.
- In recent years ex situ conservation has advanced beyond keeping threatened species in enclosures.
- Now gametes of threatened species can be preserved in viable and fertile condition for long periods using **cryopreservation techniques**, eggs can be fertilised in vitro, and plants can be propagated using tissue culture methods.
- Seeds of different genetic strains of commercially important plants can be kept for long periods in seed banks.

SOME IMPORTANT INFORMATIONS

- National Forest Policy revised in – 1988
- Biodiversity act of India was passed by the Parliament in the year-2002
- Indian Forest Act – 1927
- Biosphere Reserve Scheme – 1986
- **Wild life protection act 1972 (Revised in 1991)**

(3) BIODIVERSITY

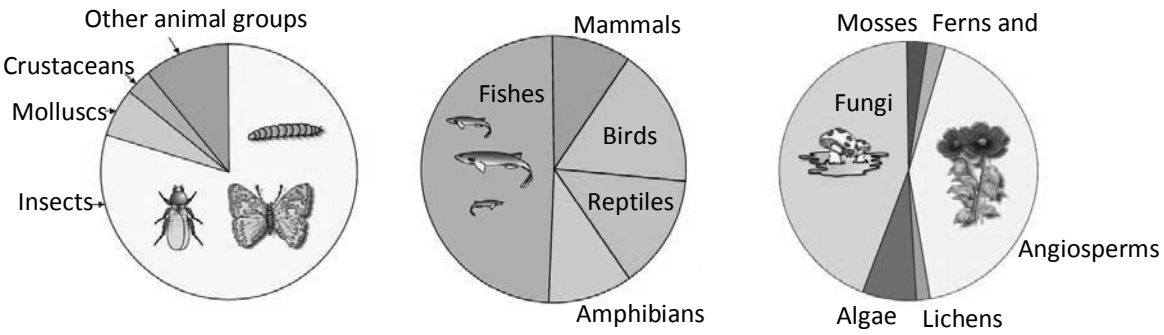
Biodiversity is the term popularised by the sociobiologist Edward Wilson to describe the combined diversity at all the levels of biological organisation.

The most important of them are

- **Genetic diversity :**
  - A single species might show high diversity at the genetic level over its distributional range.
  - The genetic variation shown by the medicinal plant Rauwolfia vomitoria growing in different Himalayan ranges might be in terms of the potency and concentration of the active chemical (reserpine) that the plant produces.
  - India has more than **50,000** genetically different strains of rice, and **1,000** varieties of mango.
- **Species diversity:** The diversity at the species level. For example, the Western Ghats have a greater amphibian species diversity than the Eastern Ghats.
- **Ecological diversity:** At the ecosystem level, India, for instance, with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows has a greater ecosystem diversity than a Scandinavian country like Norway.

(A) How Many Species are there on Earth and How Many in India :

- According to the IUCN (2004), the total number of plant and animal species described so far is slightly more than **1.5 million**, but a more conservative and scientifically sound estimate made by **Robert May** places the global species diversity at about **7 million**.
- More than **70 per cent** of all the species recorded are animals, while plants (including algae, fungi, bryophytes, gymnosperms and angiosperms) comprise no more than **22 per cent** of the total.
- Among animals, insects are the most species-rich taxonomic group, making up more than 70 per cent of the total. That means, out of every 10 animals on this planet, 7 are insects.
- The number of fungi species in the world is more than the combined total of the species of fishes, amphibians, reptiles and mammals.
- Although India has only **2.4 per cent** of the world's land area, its share of the global species diversity is an impressive **8.1 per cent**. That is what makes India one of the **12 mega diversity countries** of the world.
- Nearly 45,000 species of plants and twice as many of animals have been recorded from India.
- If we accept May's global estimates, only **22 per cent** of the total species have been recorded so far.Applying this proportion to India's diversity figures, we estimate that there are probably more than 1,00,000 plant species and more than 3,00,000 species of animals yet to be discovered.



Representing global biodiversity : Proportionate number of species of major taxa of plants, invertebrates and vertebrates [NCERT XII Page No. 260, Figure No. 15.1]

(B) Patterns of Biodiversity :

(i) Latitudinal gradients –

- The diversity of plants and animals is not uniform throughout the world but shows a rather uneven distribution.
- In general, species diversity decrease as we move away from the equator towards the poles.
- With very few exceptions, tropics (latitudinal range of 23.5° N to 23.5° S) harbour more species than temperate or polar areas.
- Colombia located near the equator has nearly 1,400 species of birds while New York at 41° N has 105 species and Greenland at 71° N only 56 species.
- **India, with much of its land area in the tropical latitudes,** has more than 1,200 species of birds.
- A forest in a tropical region like Equador has up to 10 times as many species of vascular plants as a forest of equal area in a temperate region like the Midwest of the USA.
- The largely tropical Amazonian rain forest in South America has the greatest biodiversity on earth - it is home to more than 40000 species of plants, 3000 of fishes, 1300 of birds, 427 of mammals, 427 of amphibians, 378 of reptiles and more than 125000 invertebrates. Scientists estimate that in these rainforest, there might be at least two million insect species waiting to be discovered and named.

(ii) Species-Area relationships –

- German naturalist and geographer **Alexander von Humboldt observed that within a region species richness increased with increasing explored area, but only up to a limit.**

  log S = log C + Z log A

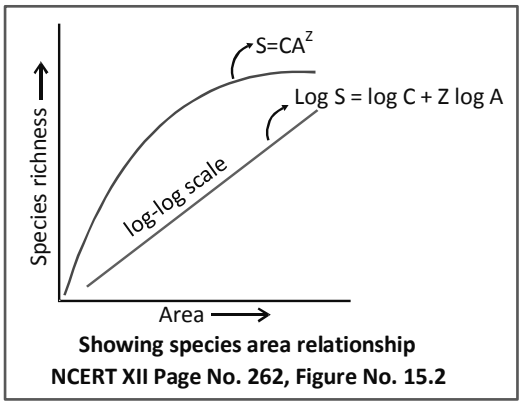
  where

  S= Species richness A= Area

  Z = slope of the line

  (regression coefficient)

  C = Y-intercept



Showing species area relationship
NCERT XII Page No. 262, Figure No. 15.2

- Ecologists have discovered for a small region (Britane, California, Newyork) the value of Z lies in the range of **0.1** to **0.2**, regardless of the taxonomic group.
- For very large areas like the entire continents the value of Z lies in the range of **0.6** to **1.2.**
- In the tropical forests of different continents for frugivorous (fruit-eating) birds and mammals value of Z found to be **1.15.**
- The **steeper slopes** in this context means more species richness.

(C) Importance of Species Diversity to the Ecosystem :

(i) David Tilman's long-term ecosystem experiment :

Tilman found that plots with more species showed less year-to-year variation in total biomass and showed that increased diversity contributed to higher productivity.

(ii) Paul Ehrlich proposed "Rivet popper hypothesis" :

In an air plane (ecosystem) all parts are joined together using thousand of rivets (species). If every passenger travelling in it starts popping a rivet to take home (causing a species to become extinct). It may not effect flight safety (proper functioning of the ecosystem) initially, but as more and more rivets are removed the plane become dangerously weak over a period of time. Further more, which rivet is removed may also be critical.

Loss of rivets on wings (Key stone species that drive major ecosystem functions) is obviously a more serious threat to flight safety.

(D) Loss of Biodiversity :

- The biological wealth of our planet has been declining rapidly and the accusing finger is clearly pointing to human activities. The colonisation of tropical Pacific Islands by humans is said to have led to the extinction of more than 2,000 species of native birds.
- The **IUCN Red List (2004)** documents the extinction of **784 species** (including 338 vertebrates, 359 invertebrates and 87 plants) in the last 500 years.
- Some examples of recent extinctions include the **Dodo (Mauritius), Quagga (Africa), Thylacine (Australia), Steller's Sea Cow (Russia)** and three subspecies **(Bali, Javan, Caspian)** of tiger.
- The last twenty years alone have witnessed the disappearance of 27 species. Careful analysis of records shows that extinctions across taxa are not random; some groups like amphibians appear to be more vulnerable to extinction. This is the fact that more than 15,500 species world-wide are facing the threat of extinction.
- Presently, **12 per cent** of all bird species, **23 per cent** of all mammal species, **32 per cent** of all amphibian species and 31per cent of all gymnosperm species in the world face the threat of extinction.
- In general, los of biodiversity in a region may lead to
  (a) decline in plant production
  (b) lowered resistance to environmental perturbations such as drought
  (c) increased variability in certain ecosystem processes such as plant productivity, water use, and pest and disease cycles.

(i) Causes of biodiversity losses :

The accelerated rates of species extinctions that the world is facing now are largely due to human activities. There are four major causes ('**The Evil Quartet**' is the sobriquet used to describe them).

(a) Habitat loss and fragmentation:

- **This is the most important cause driving animals and plants to extinction.**
- The most dramatic examples of habitat loss come from tropical rain forests. Once covering more than 14 per cent of the earth's land surface, these rain forests now cover no more than 6 per cent. They are being destroyed fast.
- The Amazon rain forest (it is so huge that it is called the **'lungs of the planet'**) harbouring probably millions of species is being cut and cleared for cultivating soya beans or for conversion to grasslands for raising beef cattle.
- Besides total loss, the degradation of many habitats by pollution also threatens the survival of many species.
- When large habitats are broken up into small fragments due to various human activities, mammals and birds requiring large territories and certain animals with migratory habits are badly affected, leading to population declines.

(b) Over-exploitation :

- Humans have always depended on nature for food and shelter, but when 'need' turns to 'greed', it leads to over-exploitation of natural resources.
- Many species extinctions in the last 500 years **(Steller's sea cow, passenger pigeon)** were due to overexploitation by humans.
- Presently many marine fish populations around the world are over harvested, endangering the continued existence of some commercially important species.

(c) Alien species invasions :

- When alien species are introduced unintentionally or deliberately for whatever purpose, some of them turn invasive, and cause decline or extinction of indigenous species.
- The **Nile perch** introduced into Lake Victoria in east Africa led eventually to the extinction of an ecologically unique assemblage of more than 200 species of **cichlid fish** in the lake.
- You must be familiar with the environmental damage caused and threat posed to our native species by invasive weed species like carrot grass (**Parthenium**), Lantana and water hyacinth (**Eicchornia**).
- The recent illegal introduction of the **African catfish Clarias gariepinus** for aquaculture purposes is posing a threat to the indigenous catfishes in our rivers.

(d) Co-extinctions :

- When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct.
- When a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate.
- Another example is the case of a coevolved plant-pollinator **mutualism** where extinction of one invariably leads to the extinction of the other.

(ii) Type of Extinction of species :

(a) Natural extinction : Due to change in environmental condition.

(b) Mass extinction : Due to catastrophs.

(c) Anthropogenic extinction : Due to human activities like hunting.

(iii) The characteristics of species particularly susceptible to extinction are :

Large body size, small population size, low reproductive rate, feeding at high trophic levels in the food chain, Fixed migratory routes and habitat and localized and narrow range of distribution.

(E) Why should we conserve Biodiversity :

There are many reasons to conserve biodiversity we can group then into three categories.

(i) Narrowly utilitarian :-

- It is concerned with direct economic benefits from nature like food, firewood, fibre, construction material, industrial products and products of medicinal importance.
- More than **25 percent** of the drugs currently sold in the market world wide are derived from plants and 25,000 species of plants contribute to the traditional medicines used by native people around the world.
- **Bioprospecting :-** Exploring molecular, genetic and species level diversity for the products of economic importance.

(ii) Broadly Utilitarian :-

- It is concentred with indirect benefits from nature, like, photosynthesis, pollination.
- This argument says that biodiversity plays a major role in many ecosystem services that nature provides Amazon forest is estimated to produce **20% of the total oxygen** in the earth's atmosphere.
- Pollination is another Service, ecosystem provide through insects.

(iii) Ethical :-

It is our moral duty to care for the well being of biodiversity and pass on our biological legacy in good order to future generations.

(4) SOME OTHER INFORMATIONS ABOUT BIODIVERSITY

(A) Diversity at the level of community – Three types :

(i) Alpha diversity : Diversity with in community.

(ii) Beta diversity : Diversity between community.

(iii) Gamma diversity : Diversity of the habitats over the total landscape or geographical area.

(B) India is divided into 10 Biogeographical regions.

(C) Wetlands :

Low lying area's covered with shallow water are called wet land's. The wet lands are transitional zones between terrestrial and aquatic area's. **6% of the world's land surface is occupy by wet lands.** For wetland conservation Ramsar Convention was held in Iran.

(i) Marshes : Wetlands where grass - like plants dominate.

(ii) Swamps : Wetlands where trees or shrubs dominate.

(iii) Reverine forest : Periodically Flooded forests found in lowland along streams.

(iv) Mangrove is salty water swamp

Significance of wet lands :

- Wetland are higly productive, provide food and habitat.
- Wetlands helps to control flooding by holding excess water.
- Ground water recharging areas.
- Help to clean and purify water run-off.
- Provides sites for fishing, boating, nature study.

(5) IMPORTANT DAYS ABOUT ENVIRONMENT

02-Feb	—	World Wetland day
03-Mar	—	World wild life day
21-Mar	—	World Forest Day
22-Mar	—	World water day
22-Apr	—	Earth Day
05-Jun	—	World Environment Day
08-Jun	—	World ocean Day
11-Jul	—	World population Day
16-Sep	—	World Ozone day
02-Dec	—	National Pollutions prevention Day (National Environment Day)
14-Dec	—	World Energy Conservation Day

Note : * 2015 Is The International Year of Soil

Golden Key Points

- Most important levels of biodiversity are genetic, species and ecological diversity.
- Conservative and scientifically sound estimate made by Robert May places global species diversity at about 7 million.
- There are two methods of conservation –
  In situ (conservation in natural habitat) and
  ex situ (conservation outside natural habitat)
- In general, species diversity decrease as we move away from the equator towards poles. Also within a region species richness increases with increasing explored area, but only up to a limit.
- The four major causes of biodiversity loss "the evil quartet" includes habitat loss and fragementation, over exploitation, Alien species invasion and co-extinction.
- Joint forest management was launched in 1980s.

BEGINNER'S BOX — BIODIVERISITY AND CONSERVATION

1. Species extinct in the wild are maintained in which of the following conservation site ?

(1) Zoological parks (2) Biosphere reserves

(3) Hot spot (4) National parks

2. Which of the following is broadly utilitarian role of ecosystem ?

(1) Dyes (2) Medicines (3) Oxygen (4) Fire wood

3. Who popularised the term biodiversity ?

(1) David Tilman (2) Edward Wilson

(3) Paul Ehrlich (4) Alexander Von Hombolt

4. Which taxonomic group is more vulnerable to extinction ?

(1) Amphibian (2) Mammal

(3) Aves (4) Fishes

5. More species in community, tends to more stability than communities with less species'. It was supported by–

(1) David Tilman (2) Paul Ehrlich

(3) Humboldt (4) Both (1) and (2)

6. More species diversity show less year to year variation in biomass, was explained by :-

(1) David Tilman (2) Paul Ehrlich

(3) Humboldt (4) Both (1) and (2)

ORGANISM, POPULATION, COMMUNITY AND SUCCESION

Que.	1	2	3	4	5	6	7
Ans.	**2**	**1**	**3**	**1**	**3**	**4**	**3**

INTER SPECIFIC INTERACTIONS

Que.	1	2	3	4	5
Ans.	**2**	**4**	**1**	**1**	**2**

BIOTIC COMPONENT, FOOD CHAIN, FOOD WAVE, ECOLOGICAL PYRAMID, PRODUCTIVITY

Que.	1	2	3	4	5	6	7	8
Ans.	**2**	**4**	**2**	**2**	**1**	**3**	**2**	**3**

ABIOTC COMPONENT OF ECOSYSTEM AND ADAPTATIONS IN ORGANISMS

Que.	1	2	3	4	5	6
Ans.	**1**	**4**	**1**	**4**	**2**	**3**

NUTRIENT CYCLE, BIOME AND BIOSPHERE

Que.	1	2	3	4
Ans.	**2**	**2**	**2**	**1**

ENVIRONMENTAL ISSUES (POLLUTIONS)

Que.	1	2	3	4	5
Ans.	**3**	**2**	**4**	**1**	**3**

BIODIVERISITY AND CONSERVATION

Que.	1	2	3	4	5	6
Ans.	**1**	**3**	**2**	**1**	**4**	**1**

⇒ Organism ⇌ Environment
⇓
Ecology

⇒ Ecology is basically concerned with four levels of biological organisation.

- Organism
- Populations
- Community
- Biomes

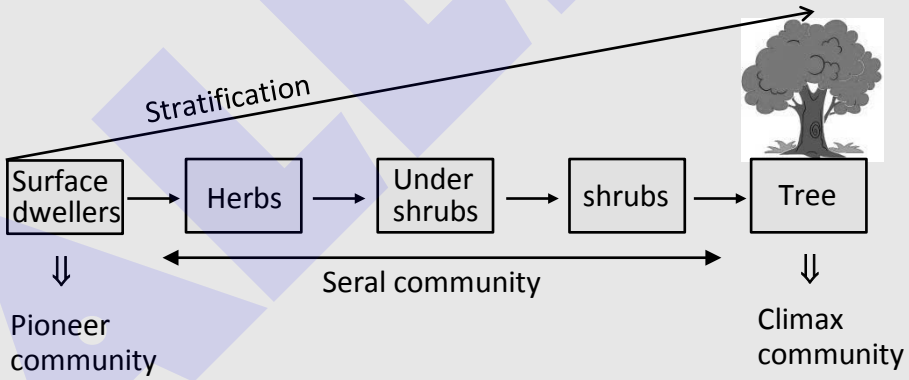
⇒ Ecology at the organismic level is essentially physiological ecology.

⇒ Population of organism inhabiting a particular area is called local population 'or' demes.

⇒ Biotic community = Animal community + Plant community + Microbial communit

Structural characterstics of a community

1. Species diversity
2. Dominance
3. Stratification



⇒ Both biotic and abiotic factors are responsible for succession.

⇒ Succession ultimately leads to climax community which is usually mesophytes.

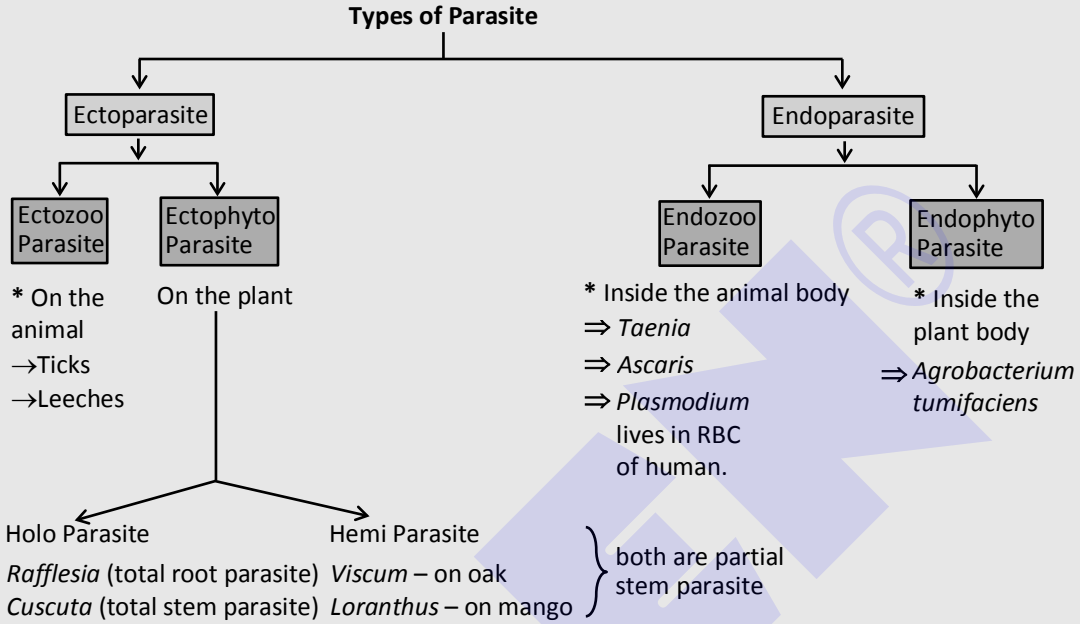
Types of succession

Primary succession
* Occurs in a barren area. (no soil)
eg.Volcanic lava
Bare Rock
Newly created pond.

Secondary succession
* Occurs in area where soil is present.
eg. Abandoned farm land, Burned 'or' cut forest, Flooded land.

Mutualism	Commensalism	Protoco-operation
• Yucca and Pronuba moth • Lichen • Miccorrhiza • Fig tree and wasp species	• Orchid & Mango • Clown fish & Sea Anemone • Barnacles and whale • Cattle erget birds & cattle.	Hermit crab-sea anemone Tick Bird – Rhinoceros Crocodile – Bird

Parasitism (+,–) :- depends on its host for food and shelter.

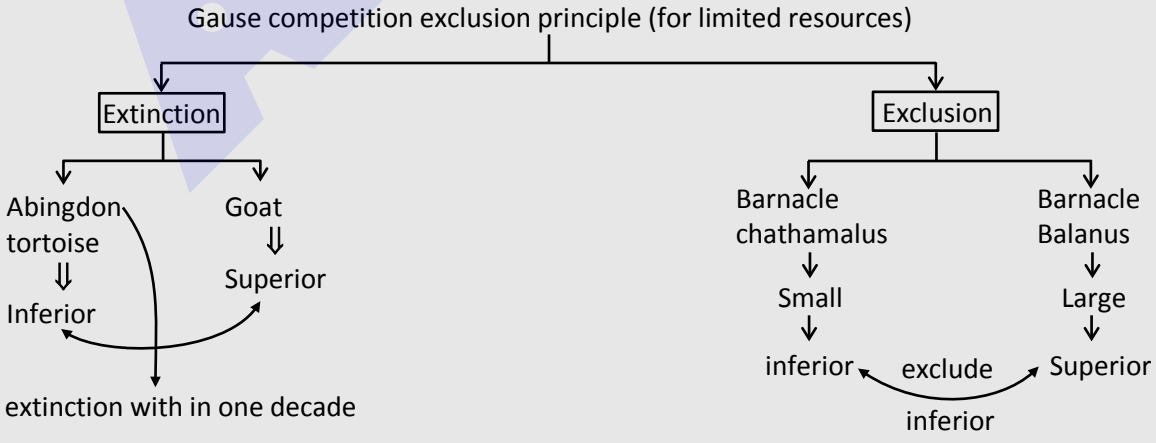


Brood Parasitism:- Parasite Bird (Cucco) ⟶ egg in crow's Nest → crow incubate.

Predation (+,–) :- Catch, Kill and Eat

eg. Lion Hunting deer.
Cow eating grass.
Sparrow eating seed.

Competition :-



Type of Ecosystem

- **Natural Ecosystem**
  - **Terrestrial Ecosystem**
    - eg. • Forest
      • Grass land
      • Desert
      • Tree
  - **Aquatic Ecosystem**
    - **Lentic ecosystem**
      - **eg.** • Lake
        • Pond
        • Swamp
    - **Lotic ecosystem**
      - **eg.** River
- **Artificial Ecosystem**
  - • Man made
    eg. – Cropland
    – Gardens

Component of Ecosystem

- **Biotic component**
  - Plant → Producer
  - Animal → Macro consumer
  - Microbe → Micro consumer
- **Abiotic component**
  - • Air
  - • Water
  - • Soil
  - • Light
  - • Temperature

Consumer

- **Macro-consumer**
  - **Primary Consumer 'OR' Secondary Producer**
    - eg. All herbivores
  - **Secondary Consumer 'OR' Primary Carnivores**
    - **eg.** Dog, Cat, Snake, Wolf
  - **Top Consumer**
    - • Kill other animal but not killed and eaten by other animal in nature.
      eg. Lion, Man.
- **Micro-consumers**
  - **eg.** • Bacteria
    • Fungi

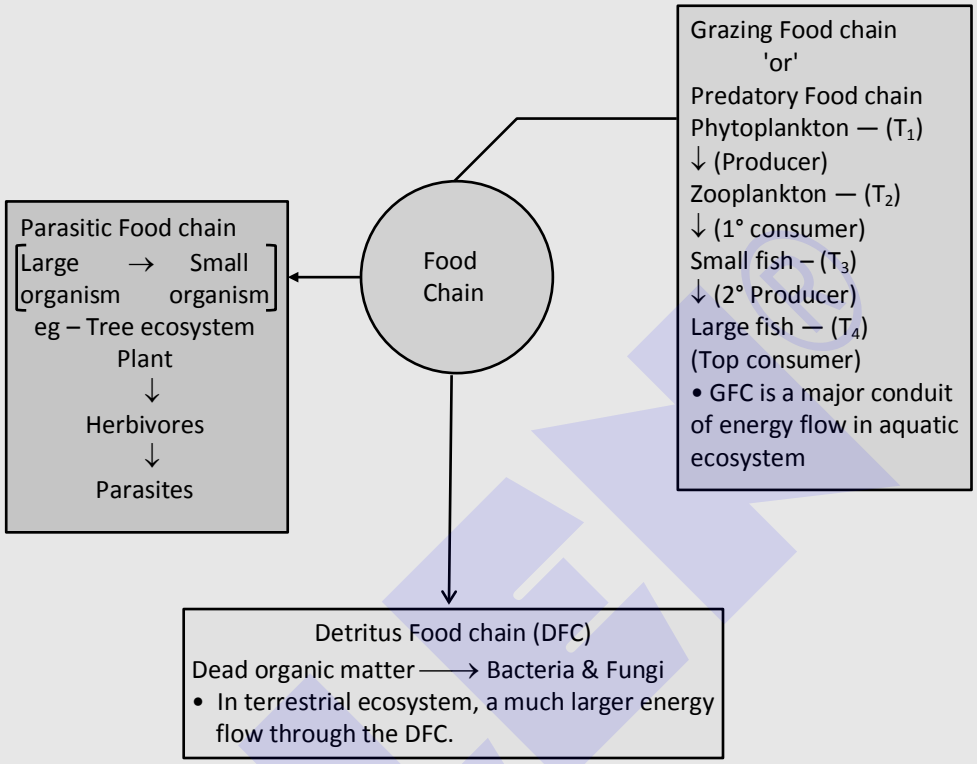
Functional Aspects of ecosystem.

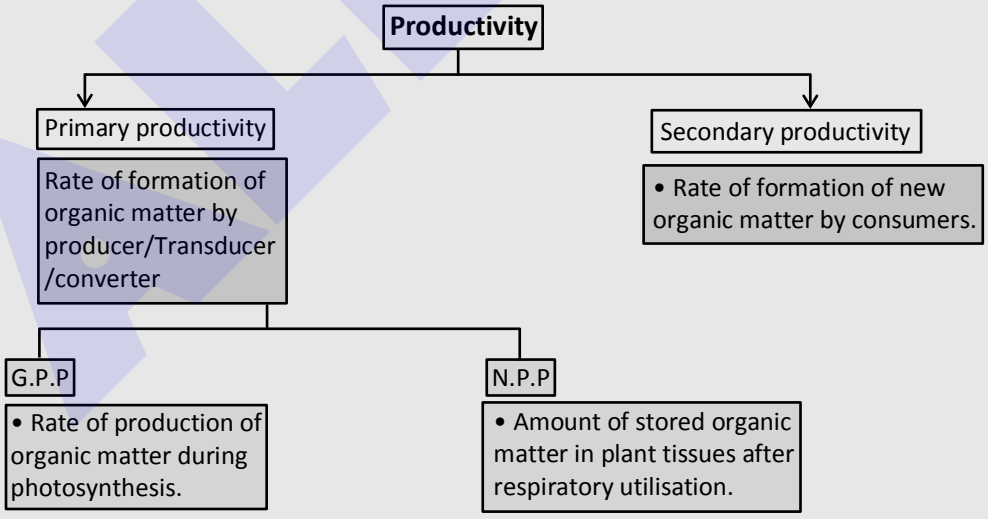
(i) Energy Flow

(ii) Nutrient cycling

(iii) Productivity

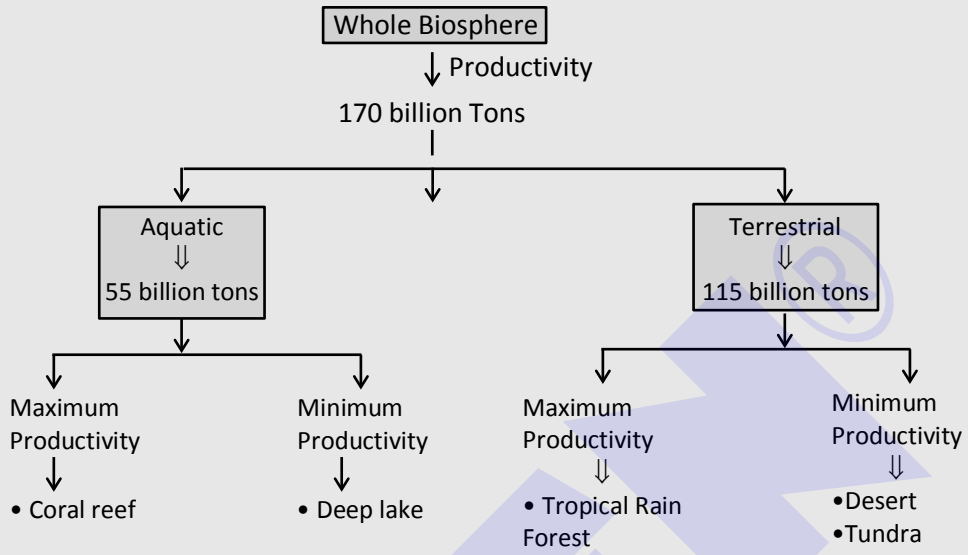
(iv) Decomposition



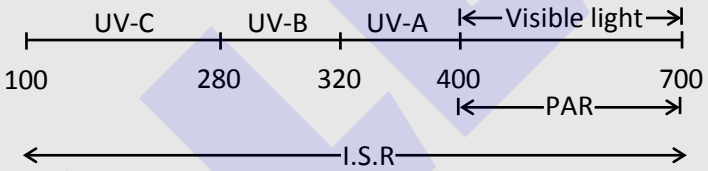


Factors affecting Primary Productivity

(a) Plant species inhabiting the area.
(b) Environmental/climatic factors like temperature, light, rainfall etc.
(c) Availability of nutrients (Soil).
(d) Photosynthetic capacity of plants.



Light :-



- UV–C → most lethal.
- UV–B → most harmful on earth surface.

Albido value :- $A.V \times \frac{1}{\text{Temperature}}$

- Fresh snow – 80 %
- Sand – 20 – 30 %
- Forest – 5 – 10%

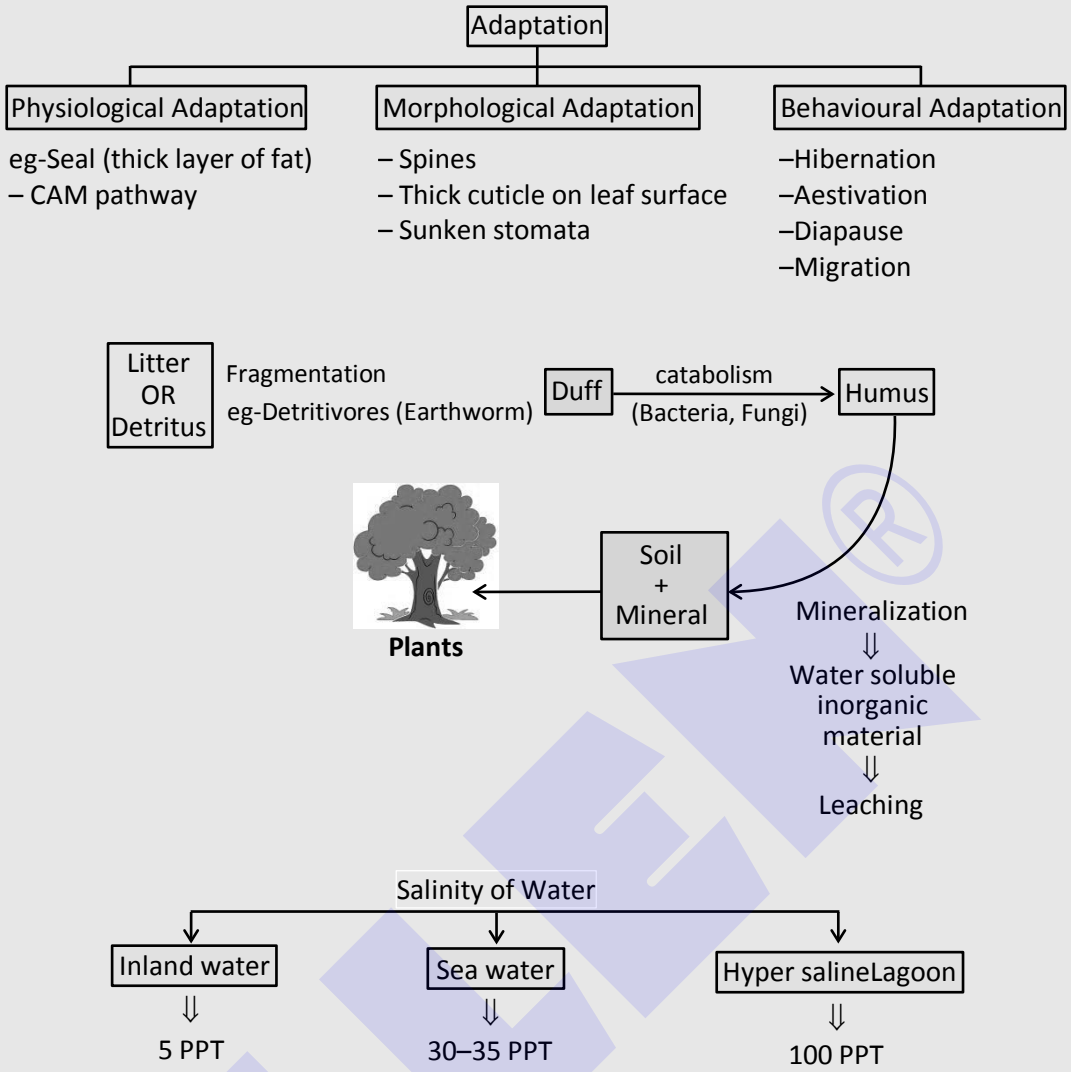
Temperature :-

- Heat loss or heat gain is a function of surface area.

Allen's Rule :-

Cold climate ⟶ Limbs, ears ⟶ short ⟶ less body heat liberated
Warm climate ⟶ Limbs, ears ⟶ Long ⟶ more body heat liberated.

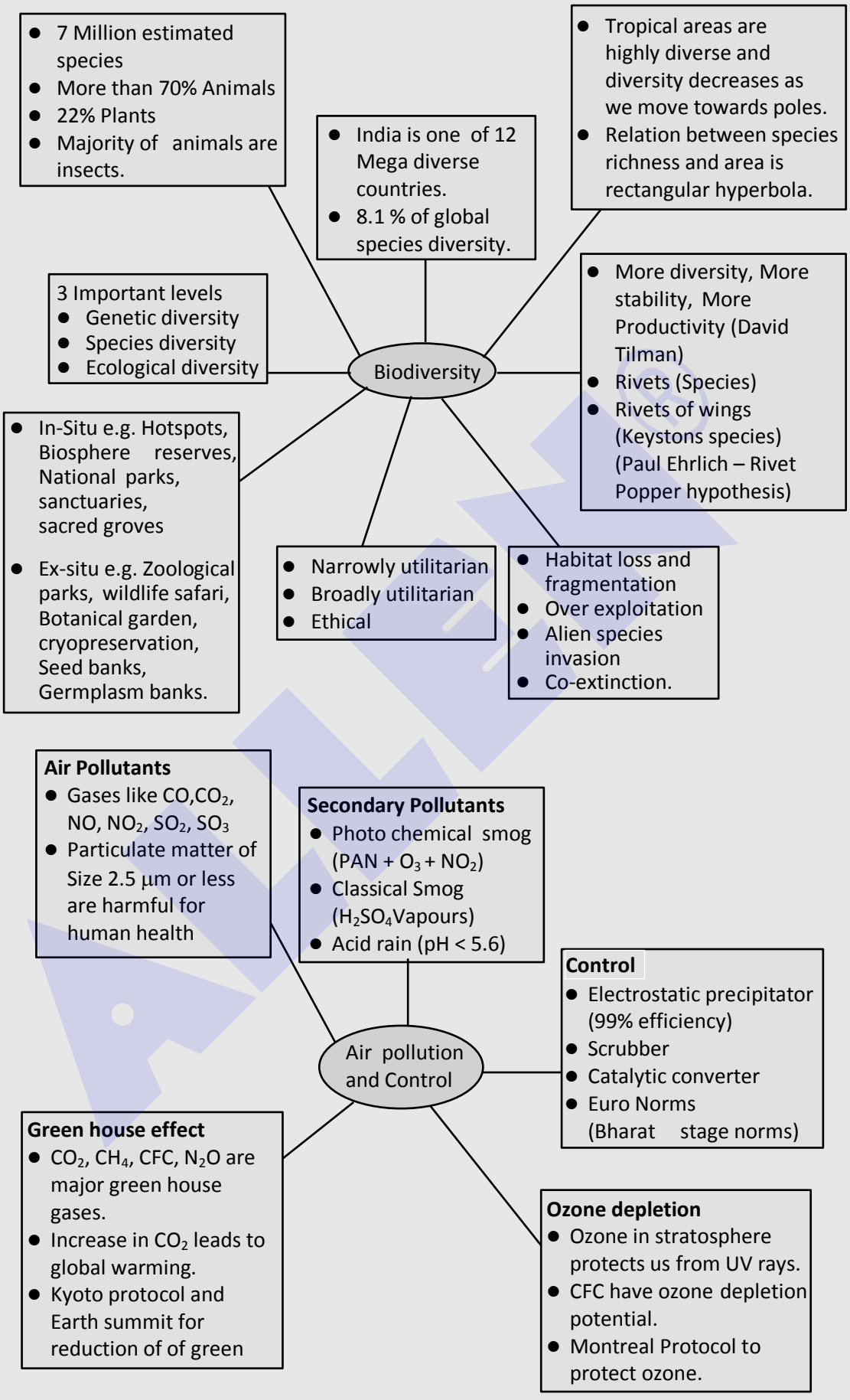
- Temperature is the most ecologically relevant environmental factor.
- Equator ⟶ Pole – temperature decreases.
- Plains ⟶ Mountains – temperature decreases.



Euryhaline ⟶ eg. – Moll fish
Stenohaline ⟶ eg. – Gold Fish

Carbon cycle :-

- 0.03 % CO_2 in atmosphere
- ≈49% of dry weight
- ≈ 71% of desolve carbon in ocean
- Annually ⟶ 4×10^{13} kg carbon ⟶ Fixed by Photosynthesis in Biosphere.


7 Million estimated species
More than 70% Animals
22% Plants
Majority of animals are insects.
India is one of 12 Mega diverse countries.
8.1 % of global species diversity.
Tropical areas are highly diverse and diversity decreases as we move towards poles.
Relation between species richness and area is rectangular hyperbola.
3 Important levels
Genetic diversity
Species diversity
Ecological diversity
Biodiversity
More diversity, More stability, More Productivity (David Tilman)
Rivets (Species)
Rivets of wings (Keystons species) (Paul Ehrlich – Rivet Popper hypothesis)
In-Situ e.g. Hotspots, Biosphere reserves, National parks, sanctuaries, sacred groves
Ex-situ e.g. Zoological parks, wildlife safari, Botanical garden, cryopreservation, Seed banks, Germplasm banks.
Narrowly utilitarian
Broadly utilitarian
Ethical
Habitat loss and fragmentation
Over exploitation
Alien species invasion
Co-extinction.
Air Pollutants
Gases like CO,CO2, NO, NO2, SO2, SO3
Particulate matter of Size 2.5 μm or less are harmful for human health
Secondary Pollutants
Photo chemical smog (PAN + O3 + NO2)
Classical Smog (H2SO4Vapours)
Acid rain (pH < 5.6)
Control
Electrostatic precipitator (99% efficiency)
Scrubber
Catalytic converter
Euro Norms (Bharat stage norms)
Air pollution and Control
Green house effect
CO2, CH4, CFC, N2O are major green house gases.
Increase in CO2 leads to global warming.
Kyoto protocol and Earth summit for reduction of of green
Ozone depletion
Ozone in stratosphere protects us from UV rays.
CFC have ozone depletion potential.
Montreal Protocol to protect ozone.

SOUND POLLUTION :

Very Quiet	20 – 30 dB	Sound quiet place is – 20 dB, Motion Picture studio, Broadcasting studio
Silence/Quiet	30/35 – 50 dB	Hospitals (30 – 35), Schools (45 – 50), Libraries (45 – 50), Offices (40 – 50)
Normal voice	55 dB	
Conversational speech	60 dB	
Moderately Loud	70 dB – 90 dB	Average traffic – 70 dB Heavy city traffic – 90 dB
Uncomfortable Painful	above 100 dB above 130 dB	Air craft (120 dB) Rocket (180 dB) Jet plane (150 dB)