

# Part 1

Date.....

ES503C : Ecology and biodiversity

U-1, U-2

Unit - 1

Introduction to ecology.

✓ Biological levels of organisation - genes to biosphere

✓ Population characteristics

✓ Biotic interaction : +ve & -ve interactions

Community dynamics : Ecological succession

✓ Concept of Niche and ecotypes.

## Biological levels of organisation - Genes to Biosphere

The various levels of organization include atoms, molecules, cells, tissues, organs, organ system, whole organisms, populations, communities, ecosystems and the biosphere.

### Molecular Level : Atoms (molecules)

Atoms are the smallest unit of matter that have the chemical properties of a particular chemical element.

Molecules the smallest particle of a substance that retains all the properties of the substance and is composed of one or more atoms.

DNA : All molecules including this DNA mol. are composed of atoms.

### Cellular level :

The cell is the smallest unit of biological organization that biologists consider alive.

All true cells are surrounded by a plasma (cell) membrane, carry out complex chemical reactions, and are at least potentially capable of self reproduction.

### Tissue level :

A tissue is a group of distinct and similar cells that carry out a specific set of functions.

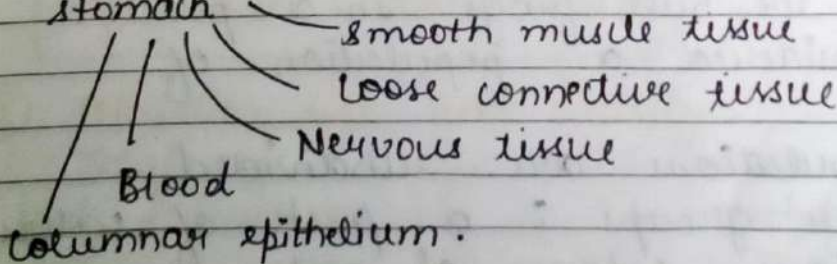
For eg : Connective tissue, Epithelial tissue, Muscle tissue, Nervous tissue.

### Organ level :

Organs are groups of tissues organized together to carry out a particular set of functions.

Organs typically have several kinds of tissues.

Organs in animals are composed of a no. of different tissue types. For eg → the stomach



### Organ system level :

Multicellular organisms, especially animals typically are organized into organ

systems, groups of organs that function together to carry out broad sets of functions.

For instance an organ system in humans is the digestive system.

Some of the organs in the digestive system are the stomach, liver, small intestine, pancreas.

### Organism level:

The organism or individual is that level of biological organization that has its own distinct existence as a complex, self-reproducing unit.

We are multi-cellular organisms in that we are made of many highly specialized cells which cannot exist independently of other cells in the organism.

### Population level:

A population is a group of freely interacting and breeding individuals of the same species.

For eg: all the bullfrogs in a pond can be considered a population of bullfrogs.

Typically populations are subdivided into smaller groups: a pack of wolves, pride of lions, colony of ants.

### Community level $\Rightarrow$

A community is all the populations of different species living and interacting together in a distinct area.

eg. all the species in a pond.

### Ecosystems (Biomes) :

Ecosystems are distinguishable groups of species and the abiotic (non-living) components of the environment with which the living creatures interact.

Eg of ecosystems include forests, prairies, deserts.

### Biosphere :

The biosphere is the region on, below and above the Earth's surface where life exists. Living things can be found well into the atmosphere, the deepest parts of the ocean, and at least in some areas, microbes live in rock several km below the surface of the earth.

## Population Characteristics

### ① Population size and Density :

Total size is generally expressed as the no. of individuals in a population.

Population density is defined as the no. of individuals per unit area unit volume of environment.

Foreg : Larger organisms as trees may be expressed as 100 trees per hectare, whereas smaller ones like phytoplanktons as 1 million per cubic metre of water.

② **Population dispersion** : Dispersion is the spatial pattern of individuals in a population relative to one another.  
 Clumped ——— Random ——— Uniform.

③ **Age structure** : The proportion of individuals in each age group is called age structure of that population.

④ **Natality (Birth Rate)** : Population increase because of natality.

No. of organisms born per female per unit time.

⑤ **Mortality (Death Rate)** : Mortality means the rate of death of individuals in the population.

⑥ **Population Growth** : The population growth rate is the rate at which the no. of individuals in a population rises in a given time period as the fraction of the initial population.

⑦ **Gender Ratio** : The Gender Ratio is the ratio of males

to females in a population .

### ⑧ Age distribution :

3 types of age distribution —

- ① Pyramid shaped
- ② Bell shaped
- ③ Urn shaped

⑨ **Immigration** : It is the movement of people into a destination country to which they are not native or do not possess its citizenship in order to settle or reside there.

### ⑩ **Emigration** :

Emigration is the act of leaving one's native country with the intent to settle elsewhere.

→ describes the movement of persons into one country from another.

~~Biotic interactions : Positive and Negative Interactions~~

**Ecological succession :** Xerosere.

Xerosere is a plant succession which is limited by water availability.

Stages of Xerosere: →

stage 1 : Crustose Lichen stage

A bare rock consists of solid surface or very large boulders and there is no place

for rooting plants to colonize.

Lichens produce acids which corrode the rock and their thalli collect wind blown soil particles among them that help in formation of a thin film of soil.

When these lichens die their thalli decomposed to humus.

This promotes soil building and the environment becomes suitable for growth of foliose and fruticose type of lichens.

### Stage 2: Foliose and Fruticose Lichen Stage

Foliose have leaf like thalli while the fruticose lichens are small bushes. They are attached by the substratum at one point only.

- Therefore do not cover the soil completely.
- They can absorb and retain more water and are able to accumulate more dust particles.
- Their dead remains are decomposed to humus which mixes with soil particles and help building substratum and improving soil moisture contents further.
- Autogenic changes favour growth and establishment of mosses.

### Stage 3: Moss Stage

Rhizoids penetrates soil among the crevices secrete acids and corrode the

rocks.

The bodies of mosses are rich in organic and inorganic compounds.

When these die they add these compounds, to the soil to increase the fertility of the soil.

Since mosses develop in patches they catch soil particles from air and help fixing substratum.

#### Stage 4: Herb stage

Herbaceous weeds mostly — their roots penetrate deep down, secrete acids and enhance the process of weathering.

- Leaf litter and death herbs add humus to the soil.
- Shading of soil results in ↓ in evaporation and there is a slight ↑ in temperature.
- As a result in ↓ in evaporation and there is a slight ↑ in temperature.
- As a result the xeric condn begin to change and biennial and perennial herbs and xeric grasses begin to inhabit.

#### Stage 5: Shrub stage

Early invasion of shrub is slow but once a few bushes have become established birds invade the area and help disperse shrub seeds.

- This results in dense shrub growth shading the soil and making conditions



unfavourable for the growth of herbs which begin to migrate.

→ Soil formation continues and its moisture contents enhance.

### Stage 6: Tree stage:

Change in environment favours colonization of tree species.

Tree saplings begin to grow among the shrubs and establish themselves.

→ Trees form canopy and shade the area.

→ Shade loving shrubs continue to grow as secondary vegetation.

→ Leaf litter and decaying roots weather the soil further and add humus to it making the habitat more favourable for growth to trees.

### Stage 7: Forest stage or climax stage

The succession culminates in a climax community, the forest.

Many intermediate tree stages develop prior to establishment of a climax community.

Forest type depend upon climatic conditions.

# Part 2

Date.....

## Unit - 2

### Ecosystem :

structural components

Functions and Productivity of an Ecosystem

Food chains

Food webs

Trophic levels

Ecological pyramids

Biogeochemical cycles

Types and characteristics of Ecosystem

terrestrial ( forest, desert, grassland )  
and aquatic ( pond, marine ).

### Structural components of an Ecosystem :

The structure of an ecosystem includes or characterised by the organisation of both biotic and abiotic components.

This includes the distribution of energy in our environment.

It also includes the climatic conditions prevailing in that particular environment.

Structure of an ecosystem can be split into two main components,

→ Biotic components

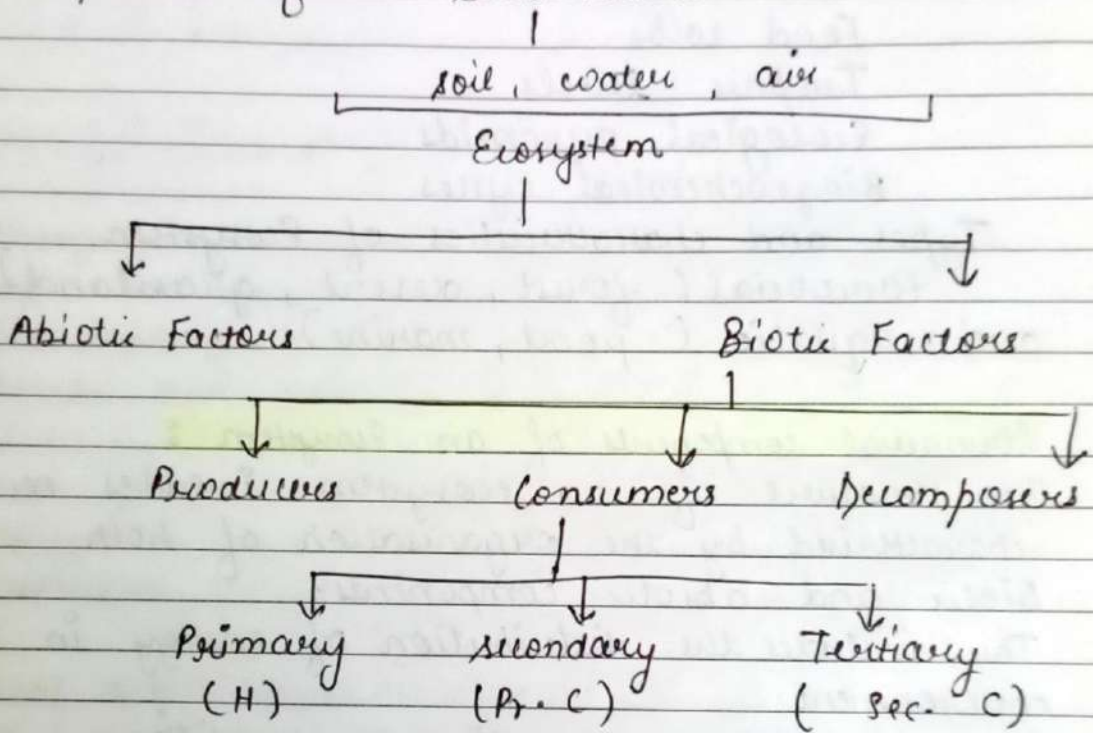
→ Abiotic components

The biotic and abiotic components are interrelated in an ecosystem.

It is an open system where the energy and components can flow throughout the boundaries.

## Ecosystem

The living community of plants and animals in any area together with the non-living components of the environment.



Biotic components  $\Rightarrow$

Biotic components refer to all life in an ecosystem. Based on nutrition, biotic components can be categorised into autotrophs, heterotrophs and saprotrophs (or decomposers).

① **Producers**: Producers include all autotrophs such as plants.

They are called autotrophs as they can produce food through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.

## ② Consumers: (Heterotrophs)

Are organisms that depend on other organisms for food.

Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.

### → Primary consumers:

Are always herbivores that they rely on producers for food.

### → Secondary consumers: depend on primary consumers for energy.

They can either be a carnivore or an omnivore.

### → Tertiary consumers: Are organisms that depend on secondary consumers for food. Tertiary consumers can also be an omnivore.

### → Quaternary Consumers: Are present in some food chains.

These organisms prey on tertiary consumers for energy.

Furthermore, they are usually at the top of a food chain as they have no natural predators.

## ③ Decomposers: It includes saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

### Abiotic Components :

Abiotic components are the non-living component of an ecosystem.

It includes air, water, soil, minerals, sunlight, temp, nutrients, wind, altitude, turbidity etc.

### Functions of an Ecosystem :

- ① It regulates the essential ecological processes, support life systems and renders stability.
- ② It is also responsible for the cycling of nutrients b/w biotic and abiotic components.
- ③ It maintains a balance among the various trophic levels in the ecosystem.
- ④ It cycles the minerals through the biosphere.
- ⑤ The abiotic components help in the synthesis of organic components that involves the exchange of energy.

So the functional units of an ecosystem or functional components that work together in an ecosystem are :

**Productivity :** It refers to the rate of biomass production.

**Energy flow :** It is the sequential process through which energy flows from one trophic level to another.

The energy captured from the sun flows from producers to consumers and then to decomposers and finally back to the environment.

**Decomposition** : It is the process of breakdown of dead organic material.  
Top-soil is the major site for decomposition.

**Nutrient-cycling** : In an ecosystem nutrients are consumed and recycled back in various forms for the utilisation by various organisms.

### Productivity :

The amount of energy available in an ecosystem determines how much life it can support.

### **Gross primary productivity** : (GPP) :

The total amount of solar energy that the producers in an ecosystem capture via photosynthesis over a given amount of time.

### **NPP** :

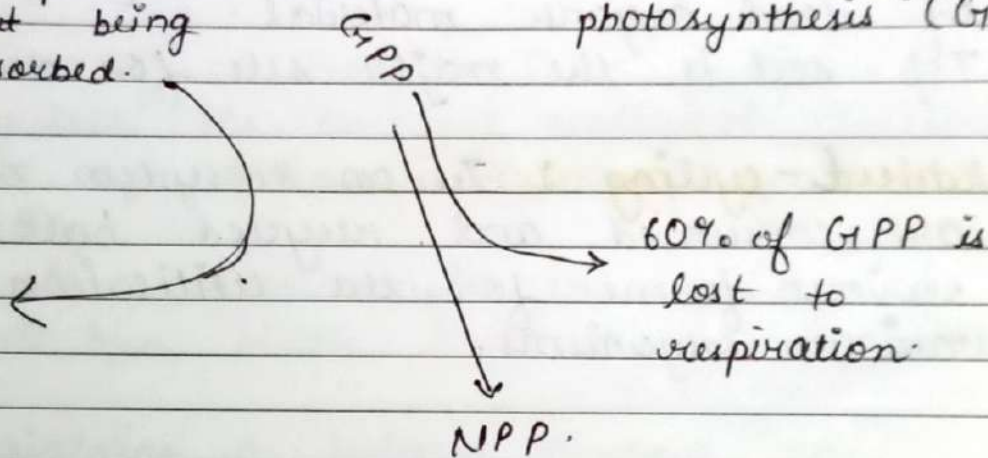
The energy captured (GPP) - the energy respired by producers.

Only NPP is available as food to organisms.

Sun

99% of solar energy is reflected or passes through producers without being absorbed.

1% of solar energy striking producers is captured by photosynthesis (GPP).



40% of GPP supports the growth and reproduction of producers (NPP).

### Primary productivity :

It is defined as the rate of which radiant energy is stored by the producers, most of which are photosynthetic, and to a much lesser extent the chemo-synthetic microorganisms.

Primary productivity is of following types :

- a) **Gross primary productivity** : Total rate of photosynthesis including the organic matter used up in the respiration during the measurement period.

### b) Net primary productivity :->

Also known as apparent photosynthesis or net assimilation, it refers to the rate of storage of organic matter in plant tissues in excess of the respiratory utilisation by plants during the measurement period.

### Secondary productivity :->

It is the rate of energy storage at consumer's level - herbivores, carnivores and decomposers.

Consumers tend to utilise already produced food materials in their respiration and also convert the food matter to different tissues by an overall process.

### Net Productivity :-

It refers to the rate of productivity storage of organic matter not used by the heterotrophs or consumers i.e. equivalent to net primary production minus consumption by the heterotrophs during the unit period.

### Food chains :-

A food chain is a linear sequence of organisms through which nutrients and energy pass as one organism eats another.



or

The sequence of organism through which the energy flows, is known as food chain.

Let's look at the parts of a typical food chain, starting from the bottom - the producers - and moving upward.

→ At the base of the food chain lie the primary producers.

The primary producers are autotrophs and are most often photosynthetic organisms such as plants, algae or cyanobacteria.

→ The organisms that eat the primary producers are called primary consumers. Primary consumers are usually herbivores, plant-eaters, though they may be algae eaters or bacteria eaters.

→ The organisms that eat the primary consumers are called secondary consumers. Secondary consumers are generally meat-eaters - carnivores.

→ The organisms that eat the secondary consumers are called tertiary consumers. These are carnivore - eating carnivores, like eagles or big fish.

→ Some food chains have additional levels, such as quaternary consumers - carnivores that eat tertiary consumers.

Organisms at the very top of a food chain are called apex consumers.

The energy efficiency of each trophic level is very low. Hence, shorter the food chain greater will be the accessibility of food.

Types of food chains :-

### ① Grazing food chain :-

The consumers utilizing plants as their food, constitute grazing food chain.

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

→ Most of the ecosystem in nature follows this type of food chain.

Eg: Grass → Grasshopper → birds → falcon.  
Flower → Caterpillars → Frog → snake → Owl  
(P) (consumer) (C) (C) (C)

→ Depend on direct influx of solar radiation

### ② Detritus food chain :-

This type of food chain starts from dead organic matter of decaying animals and plant bodies to the micro-organisms and then to detritus.

feeding organism and to other predators.

- The food chains depends mainly on the influx of organic matter produced in another system.
- The organism of the food chain includes algae, bacteria, fungi, protozoa, insects, nematodes etc.

Dead organic matter → Microscopic orgn. → Detritivore org. like snails, earthworms.

- Depend on direct influx of organic matter.
- Less dependent on direct solar energy.

Significance of food chain :

- ① The knowledge of food chain helps in understanding the feeding relationship as well as the interaction b/w organism and ecosystem.
- ② It also helps in understanding the mechanism of energy flow and circulation of matter in ecosystem.
- ③ It also helps to understand the movement of toxic substance and the problem associated with biological magnification in the ecosystem.

## Food Webs :

Food web can be defined as, " a network of food chains which are interconnected at various trophic levels, so as to form a no. of feeding connections amongst different organisms of a biotic community."

It is also known as consumer - resource system

- ① A node represents an individual species, or a group of related species or different stages of a single species.
- ② A link connects two nodes. Arrow represents links and always go from prey to predator.
- ③ Lowest ~~bas~~ trophic level → Basal species
- ④ Highest trophic level → Top predators.
- ⑤ Movement of nutrients is cyclic but of energy is unidirectional and non-cyclic.

There are five linear food chains in the food web of a grass land -

Grass → Grasshopper → Hawk

Grass → Grasshopper → Lizard → Hawk

Grass → Rabbit → Hawk

Grass → Mouse → Hawk

Grass → Mouse → Snake → Hawk.

The food webs are important in maintaining the stability of an ecosystem in nature. For eg: ↓ in the population of rabbit would naturally cause an ↑ in the population of alternative herbivore, the mouse.

Significance:

Food webs are important tools in understanding that plants are the foundation of all ecosystems and food chains, sustaining life by providing nourishment and oxygen needed for survival and reproduction.

### Trophic Levels:

Each step in the flow of energy through food chain in an ecosystem is known as Trophic level.

Producers → First Trophic level

Herbivores → second

Carnivores that eat herbivores → Third T.L

Carnivores that eat other carnivores are fourth trophic level.

Ecological pyramids: The graphical representation of the trophic structure and also trophic function is referred to as "Ecological pyramids".

Ecological pyramids may be of 3 general types:

- ① The pyramid of Numbers
- ② The pyramid of Biomass
- ③ The pyramid of Energy

1, The pyramid of Numbers :-

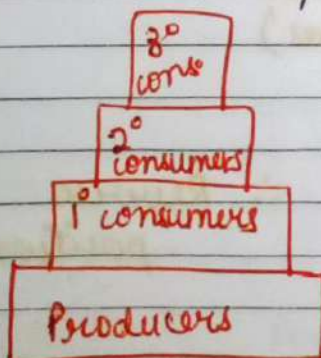
They show the relationship b/w producers, herbivores and carnivores at successive trophic levels in terms of their no.

In a grassland ecosystem, the producers which are mainly grasses are always maximum in no.

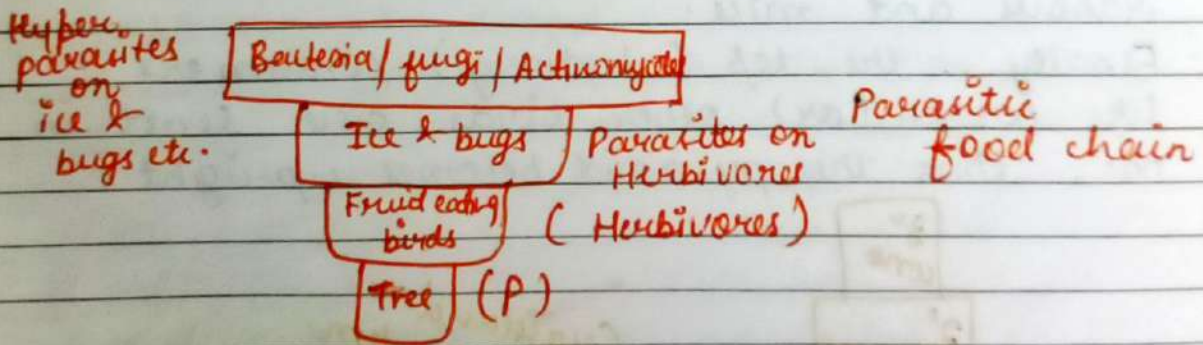
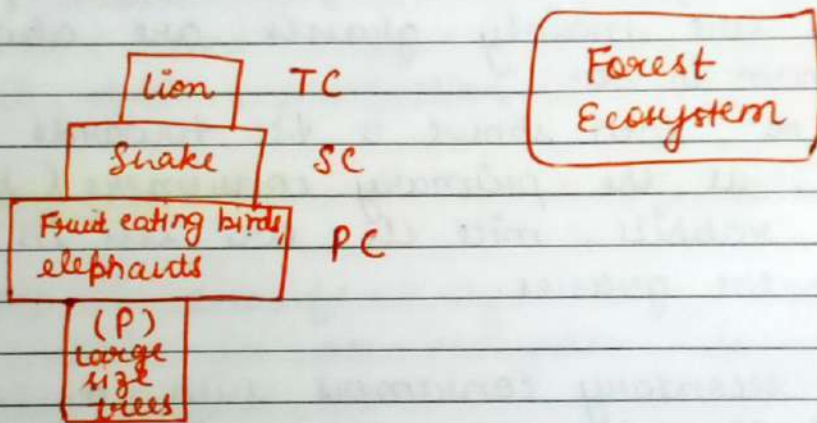
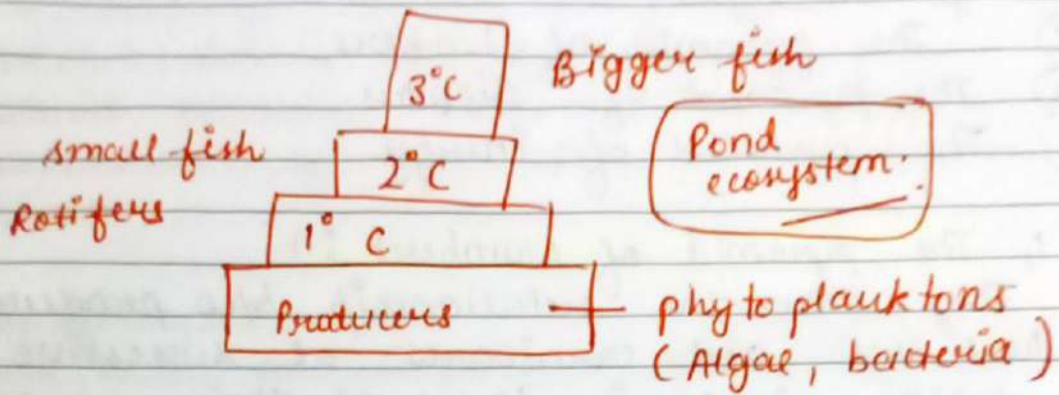
This no. then shows a  $\downarrow$  towards the apex, as the primary consumers (herbivores) like rabbits, mice etc are less in no. than the grasses.

The secondary consumers such as snakes and lizards are lesser in no. than rabbits and mice.

Finally, the top (tertiary) consumers like hawks (or) other birds are least in no., thus the pyramid becomes upright.



Grassland ecosystem.



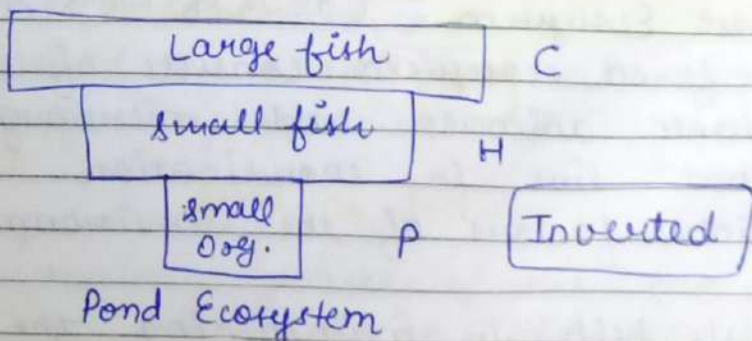
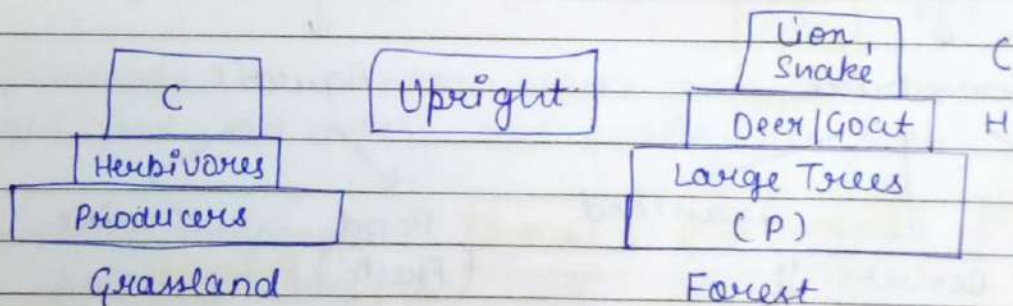
Inverted in shape. ∴ Reverse position

② Pyramid of Biomass :

A biomass pyramid is the representation of total living biomass or organic matter present at different trophic levels in an ecosystem.

i) In grassland and forest, generally there is a gradual  $\downarrow$  in biomass of organisms at successive levels from producers to the top carnivores. (Pyramids are upright).

ii) However, in a pond ecosystem, the producers are small organisms and hence their biomass is least. This value gradually shows an  $\uparrow$  towards the apex of the pyramid - pyramid inverted.

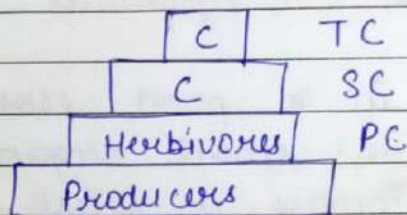




### ③ Pyramid of Energy :-

In this pyramid, the no. and weight of organisms at any trophic level depends on the rate at which food is being produced but not on the amount of fixed energy at any level in a given time.

shape → Upright



### Types and Characteristics of ecosystem :-



**Forest Ecosystem** :- (40% of total land).

→ A forest ecosystem consists of several plants, animals and microorganisms that live in coordination with the abiotic factors of the environment.

→ Forests help in maintaining the temperature

of the earth and are the major carbon sink

Forests in India can be broadly divided into coniferous forests and broad-leaved forests

↓  
Grow in Himalayan mountain region where the temp. are low.  
Needle-like leaves  
Downward sloping branches

↓  
several types - evergreen forests, deciduous forests, thorn forests and mangrove forests

**Grassland Ecosystem:** (19%) earth's surface

In a grassland ecosystem, the vegetation is dominated by grasses and herbs.

Temperate grasslands, savanna grasslands are some of the examples of grassland ecosystems.

Grasslands cover areas where rainfall is usually low and soil depth and quality is poor.

Various components:

(1) Abiotic substances:

These include the nutrients present in the soil and the aerial environment.

Elements required by plants are hydrogen, oxygen, nitrogen, phosphorus and sulphur.

(2) Primary producers:

These are mainly grasses of the family Graminae, a large variety of herbs,

some shrubs and scattered trees.

- ③ Consumers: Herbivores such as grazing mammals (eg. cow, sheep, deer, rabbit), insects, some termites and millipedes are the primary consumers.

Animals like fox, jackals, snakes, frogs, lizard, birds etc are the carnivores feeding on herbivores. (secondary consumers).

Hawks occupy the tertiary trophic level as these feed on the secondary consumers.

- ④ Decomposers: These include bacteria of death and decay, moulds and fungi. These bring the minerals back into the soil to be available to the producers again.

**Desert Ecosystem**: (17% of land).

Desert are found throughout the world. These are regions with very little rainfall. The days are hot and the nights are cold.

The various components of desert ecosystem are:

- ① Producers: The shrubs, bushes, grasses and some trees are the main producers in deserts.

- ② **Consumers**: The most common animals are those reptiles and insects which are able to live under arid conditions.  
Mammals — nocturnal rodents  
some birds are present  
Camel, called the ship of desert  
Larger animals including carnivores are scarce.
- ③ **Decomposers**: Due to poor vegetation and less amount of dead organic matter decomposers are few.  
They are thermophilic fungi and bacteria.

### Aquatic Ecosystem:

Aquatic ecosystems are ecosystems present in the body of water.

These can be further divided into two types, namely:

#### ① Freshwater Ecosystem

The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams and wetlands.

These have no salt content in contrast with the marine ecosystem.

#### ② Marine Ecosystem:

The marine ecosystem includes seas and oceans. These have a more substantial salt content and greater biodiversity in comparison to the freshwater ecosystem.