2018

IASBABA

[ENVIRONMENT-PART 1]

Integrated Learning Programme 2018 is a step towards 'Enabling a person located at the most remote destination a chance at cracking AIR 1 in UPSC/IAS'

CONTENTS

ECOLOGY

Ecology

- It is derived from 2 words –
  - "Okios" means house or environment
  - "logos" meaning study of.
- Ecology is the scientific analysis and study of interactions among organisms and their environment.
- It is not synonymous to Environment.
- It is closely related to evolutionary biology, genetics and ethology.
- This term was first given by Biologist Hackle in 1869.
- Ancient Indian texts also throw light on ecological principles. Vedas, Samhitas, Brahamanas, Aryankas-Upanishads contain many references to ecological concepts.
- Charak Samhita *(a Sanskrit text on Ayurveda)* and Sushruta Samhita (*an ancient Sanskrit text on medicine and surgery)* shows that even earlier also people have good understanding of plant and animal ecology.

Environment

- When we say environment it simply means surroundings.
- Environment is biotic (living organisms) and abiotic (non-living organisms) surrounding of an organism or population and also includes the factors that have an influence in their survival, development and evolution.
- Environment is our basic life support system. It provides the air we breathe, the water we drink, the food we eat and the land where we live.

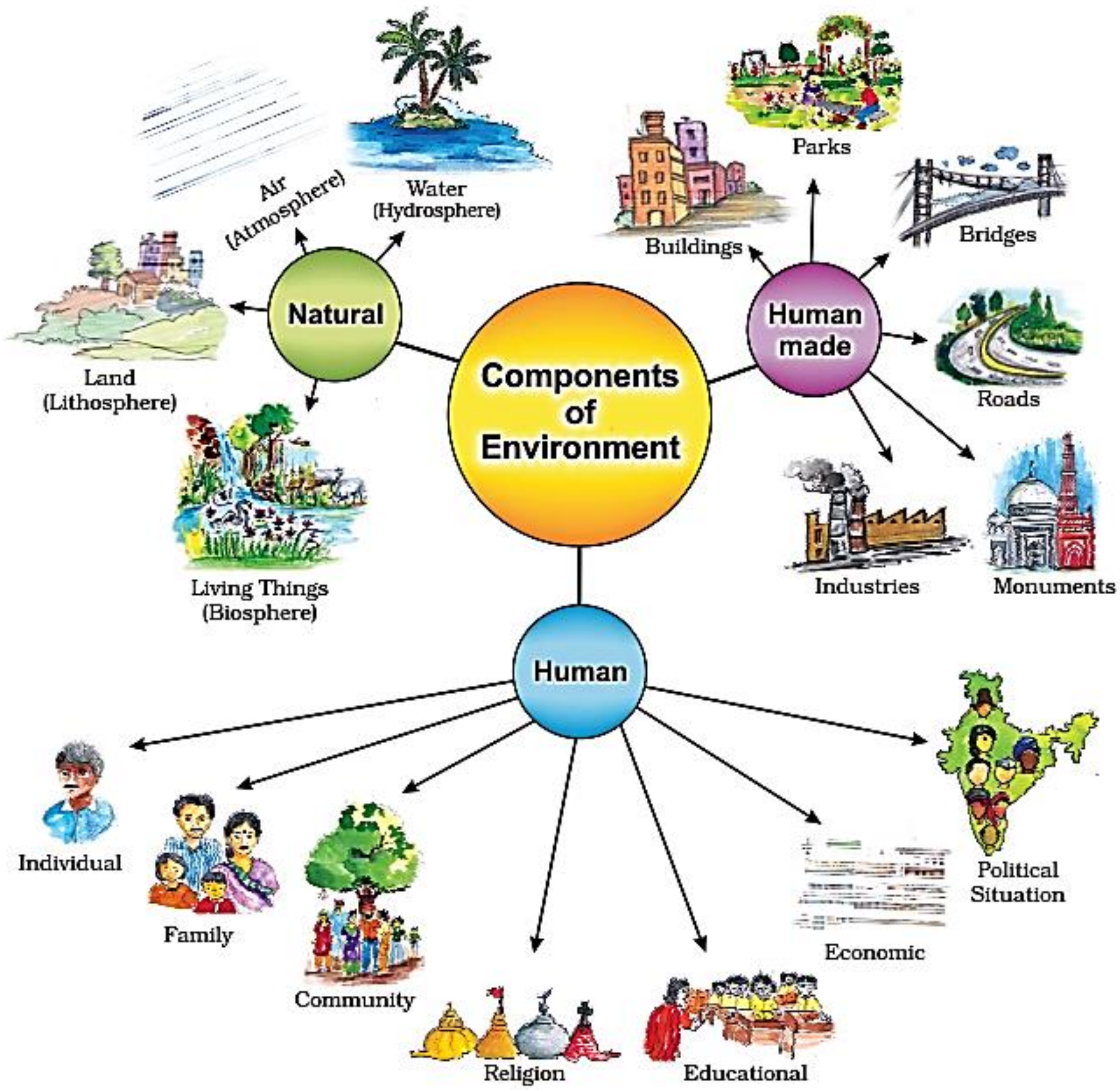


Fig. 1.1: Components of Environment

Figure 1 Components of environment

Relationship between an organism and environment

- The relationship is highly complex.
- Each organism's environment consists of other organisms as well.
- An organism cannot survive without interacting with other organisms.
- Everything which is needed for our survival or interaction forms part of environment.
- Environment is dynamic and not static.
- For example – environment of a fish in pond.

- **External environment**

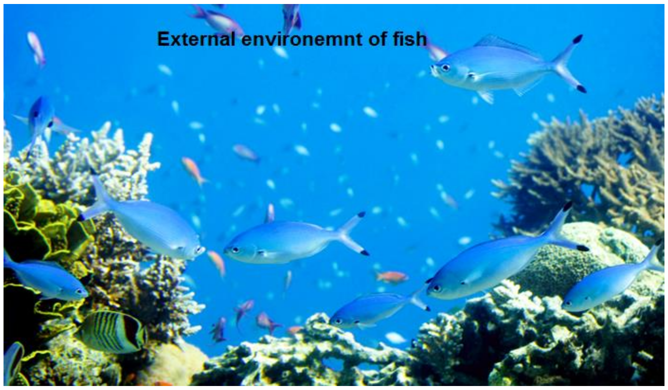


Figure 2 External environment of fish

  - Abiotic components – temperature, light, water with nutrients rich, oxygen dissolved.
  - Biotic components – Planktons, aquatic plants and animals.

- **Internal environment**

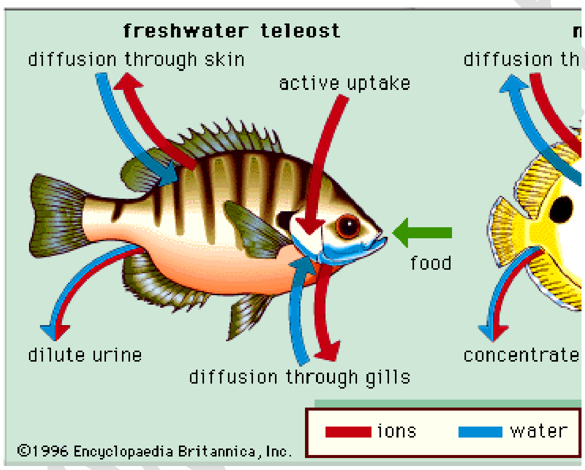


Figure 3 Internal environment of fish

  - Outer body surface
  - Stable than external environment but not absolutely constant. Injury etc. upsets the internal environment.
  - If a marine fish is transferred to fresh water environment, it will not be able to survive.

Levels of Organizations in Ecology

There are six organizations –

Figure 4 Levels of organizations in Ecology

Individual or Organism

- The basic living system, a functional grouping of the lower-level components, including at least one cell
- Example – plant, animal, bacteria, fungi etc.
- As you have seen in the above diagrams individual's body is made up of organs, organelles which help in carrying out various processes of life.

Population

- A population is a group of organisms of same species, which live in a particular geographical area, and have the capability of interbreeding.
- The individuals in a population competes or share for similar resources and interbreed.
- Example – teakwood trees in forest, bacteria in a culture plate, lotus plants in a pond.

Population Attributes

- **Per Capita birth (birth rate) –** number of live births per 1,000 people.
- **and per capita death (death rate)** – number of deaths per 1,000 people.
- **Sex ratio** - ratio of males to females in a population.
- **Population density** – Relation between the number of individuals of a population and area they occupied.
- **Age Pyramid** – A graphical illustration that shows the distribution of various age groups in a population. Also known as population pyramid or age picture.

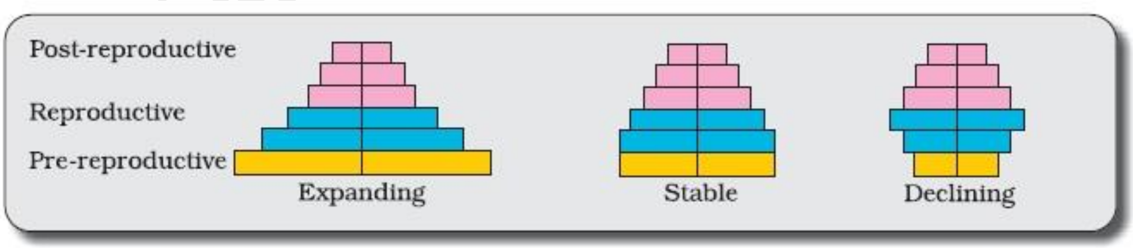


Figure 13.4 Representation of age pyramids for human population

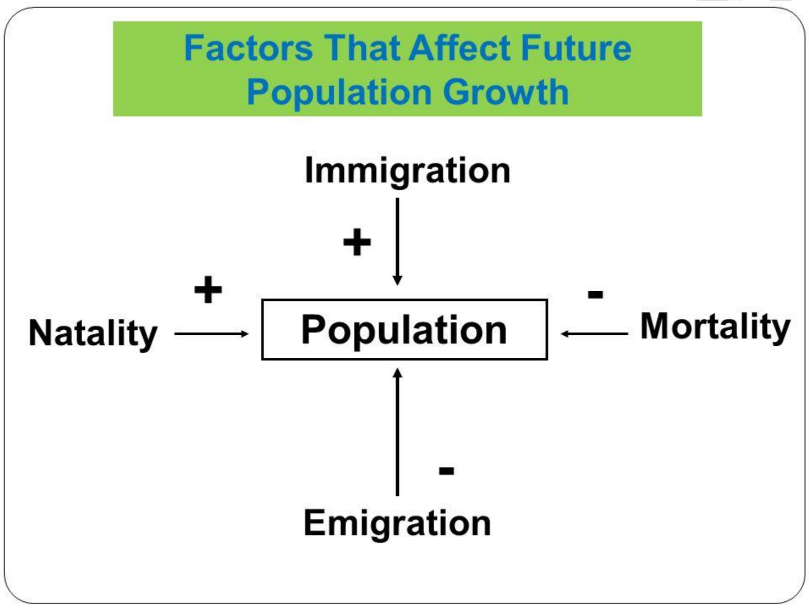
Figure 5 Age pyramid

- Size of the population tells status in the habitat.

- Population density is not measured always in no. because biomass is more meaningful to measure population size. Like population density measurement in no. is not meaningful in these cases –
    i. If one specie role is important than other species.
    ii. If population cannot be counted.
    iii. If population counting is time consuming.

Population Growth Rate

- Change in the population density between two different time periods or the difference between the birth rate and the death rate of a country. It can be –ve as well as +ve.



- Natality (birth) and Immigration contributes to +ve growth of population.
- Mortality (death) and Emigration contributes to –ve growth of population.
- **Natality** – No. of births in a population during given period.
- **Mortality** – No. of deaths in a population during given period.
- **Immigration or In-migration** – movement of individuals of same species into a habitat from elsewhere. E.g. movement of people into a country (Syrian refugees entering into European countries)
- **Emigration or Out-migration** - movement of individuals of population from habitat to elsewhere. E.g. movement of people out of a country (Syrian people moving out from their country)
- **Growth model** – population growth – time graph which helps in finding some patterns.

i. **Exponential growth –** Any species growing exponentially under unlimited resources conditions can reach enormous population densities in a short time. It had J-shaped curve.

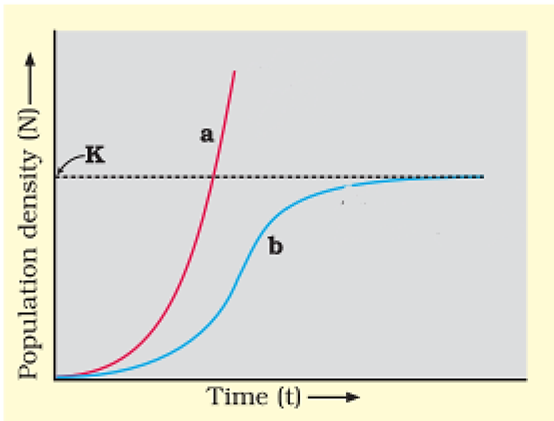


Figure 13.5 Population growth curve **a** when responses are not limiting the growth, plot is exponential, **b** when responses are limiting the growth, plot is logistic, **K** is carrying capacity

ii. **Logistics growth** – In reality there is no unlimited resources for population of any species. This leads to competition between individuals and fittest will survive. Over the period of time governments of countries had realized this and so they try to limit human population. Nature has a fix capacity for carrying or supporting a particular species population for limited resources.

- In such conditions initially population show lag phase after which it accelerates and finally asymptote.
- It had sigmoid graph.

Population Interaction or Biotic Interaction

- Every species need at least one species to interact or survive. Without other species, the single specie cannot survive. We cannot imagine a habitat on earth which is inhabited by single species.
- Example – Even plants need microbes to breakdown organic matter and return the inorganic nutrients for absorption. Plants also needed animal agents to for pollination.
- In other words, plants, animals and microns do not and cannot live in isolation but interact in various ways to form a biological community.

- Interspecific interactions arise from the interaction of population of two different species. And this interaction can be beneficial, detrimental or neutral to the one or both.

Species A	Species B	Type of interaction
+	+	Mutualism
-	-	Competition
+	-	Predation
+	-	Parasitism
+	0	Commensalism
-	0	Amensalism

Some types of relationships listed by the effect they have on each partner. '0' is Neutral, '-' is detrimental, and '+' is beneficial.

Predation

- What would happen if only plants are there but no animals to eat them? So, Predation is a nature's way to transfer energy from lower trophic level to higher trophic level.
- Example - a spider eating a fly caught at its web is a predator. Spider is getting food and so spider is benefitted while it is detrimental for fly.

+	-	Predation

- Animals that eat plants are called as herbivores. But they are no different from Predators.
- **Predator importance**
  - Transfers energy across trophic levels.
  - Keep population control. Otherwise exotic species can invade an area in the absence of predator. Example – Cat for rats and Birds for insects.

- Maintain species biodiversity by reducing competition among competing prey species.
- If predator overexploits prey. Both can become extinct and so predators are prudent and preys have self defense mechanisms to lessen the impact of predation. Example – Monarch butterfly is very distasteful to its predator and Calotropis plant produces poisonous cardiac glycosides and so no cattle eats it.

Figure 6 Monarch butterfly

Figure 7 Calotropis

Competition

- It is defined as process in which fitness of one species is significantly lower in presence of another species.
- Superior specie will knock out another species in case of competition for limited resources.
- Competition not only occurs between same kinds of species it also occurs between totally unrelated specie as well. For example – In South American lakes flamingoes and fishes both compete for common food zooplankton in lake.

-	-	Competition

- Limited resources are not necessary for competition to occur.
- Competitive release is also one of the factors for competition. Competitive release occurs when one of two species competing for the same resource disappears; thereby allowing the remaining competitor to utilize the resource more fully than it could in the presence of the first species.
- Herbivores are more affected by competition than carnivores.
- Gause competitive exclusion principle – 2 closely related species competing for same resources cannot exist indefinitely and the competitively inferior one will be eliminated eventually. But this is true only when resources are limited. (you can think example of

your brother or sister fighting for laptop if it is only one in home but you will not fight if there are two (not limited resources))

- Competition not always excludes the others as other species might evolve some mechanisms to promote co-existence rather than exclusion.
- One of such mechanism is resource partitioning in which 2 species can avoid competition by choosing different time period for feeding or different foraging patterns. For example – 5 species of warblers were living on the same tree. They were able to avoid competition and coexist because of behavioral differences in foraging patterns.

Parasitism

- It ensures free lodging and meals.

+	-	Parasitism

- It is evolved in many taxonomic groups from plants to higher vertebrates.
- Example – cascuta (see video to understand how it gets its food)
- Many parasites are host specific (can parasitize only a single species of host) in such a way that both host and parasite tend to co-evolve i.e. if host evolves some mechanism to counter parasite then the parasite also evolves mechanism to counter the host mechanisms.
- Example of parasite mechanism can be loss of unnecessary sense organs, presence of adhesive organs or suckers to cling on the host, loss of digestive system.
- The life cycle of parasite is very complex and they need to vectors or host to complete their life cycle.
- **Have you heard about malarial parasite?** The malarial parasite needs a vector (mosquito) to spread to other hosts. Similarly, human liver fluke requires 2 intermediate hosts (a snail and a fish) to complete its life cycle. (see images below)

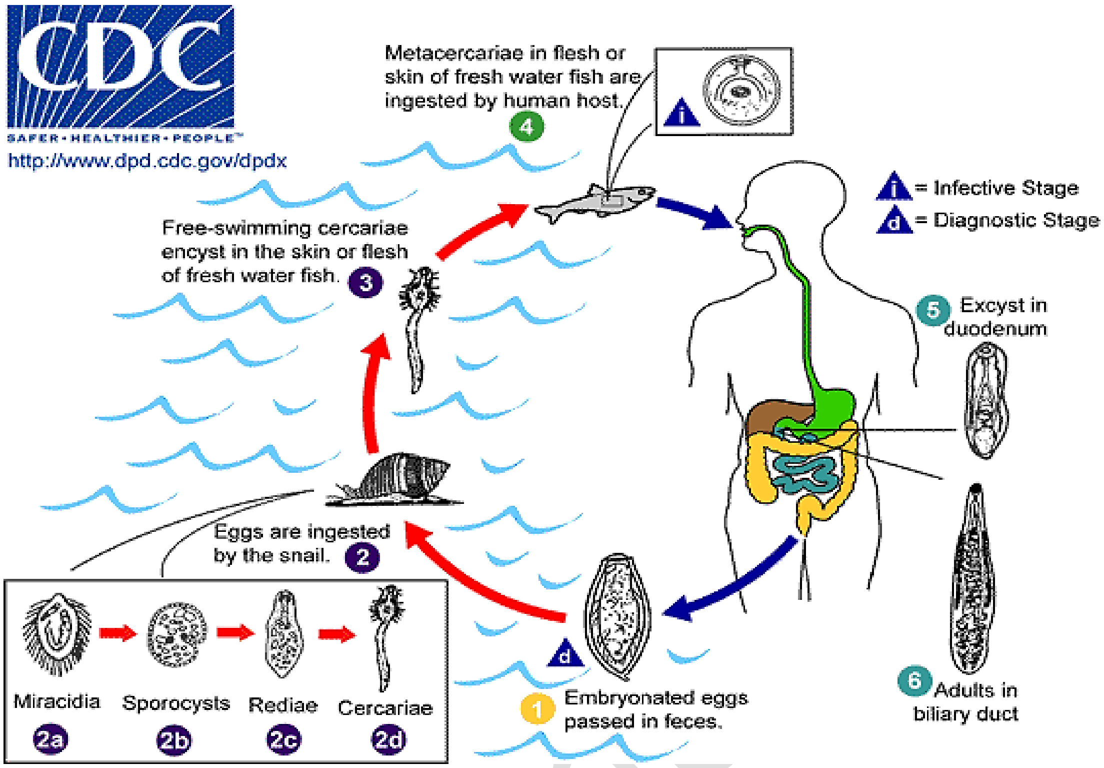
- 

Figure 8 life cycle of malarial parasite

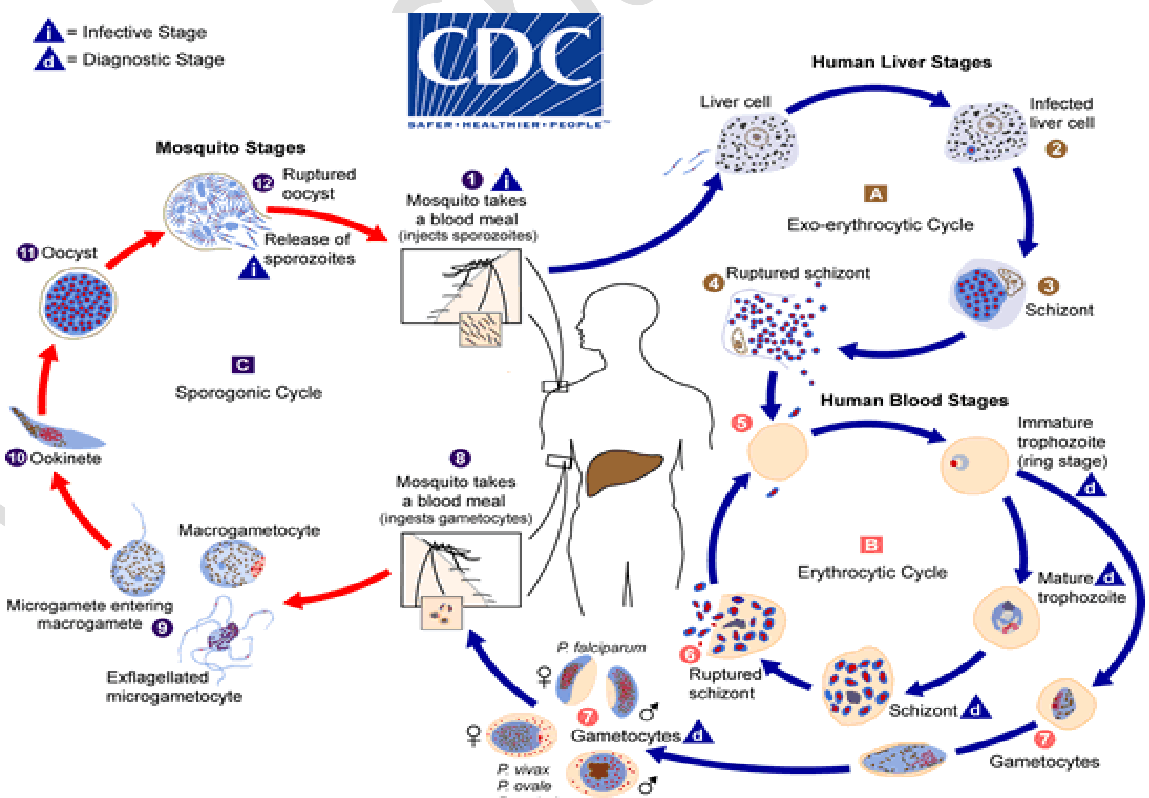
- 

Figure 9 life cycle of Human liver fluke

- Most of the parasites harm the host. They might render the host more vulnerable to predation by making it physically weak.
- **Ectoparasites** – parasites that feed on the external surface of the host organisms. Example – lice on humans, many marine fish infested with copepods, Cascuta grow on hedging plants. They derive their nutrition from the host.

Figure 10 Marine fish infested with copepods

Figure 11 Head lice

- **Endoparasites** - Those parasites that live inside the host body at different sites (liver, kidney, lungs, red blood cells, etc.).
- **Brood parasitism** – In this parasitism, parasites rely on others to raise their young.
  - The strategy appears among birds, insects and some fish.
  - The brood parasite manipulates a host, either of the same or of another species, to raise its young as if it were its own.
  - Example – Cuckoo (parasite) lays its eggs in the nest of Crow (host) and lets the crow incubate them. During the course of evolution, the eggs of the Cuckoo have evolved to resemble the crow's egg in size and colour to reduce the chances of the crow detecting the foreign eggs and ejecting them from the nest.

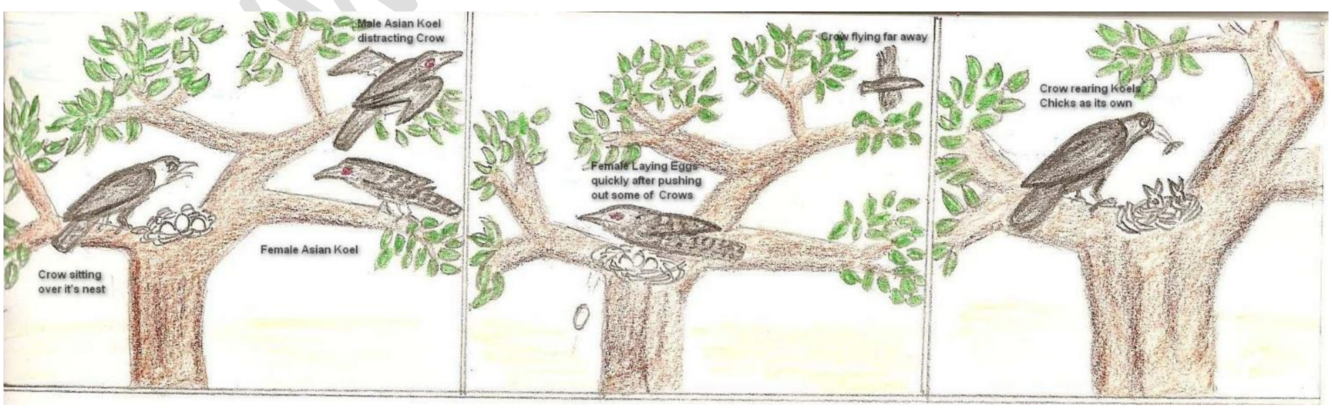


Figure 12 Brood parasitism (click here for larger image)

Commensalism

+	0	Commensalism

- In this interaction one species benefits (+) and the other is neither harmed nor benefitted. (0) example –
- An orchid growing as an epiphyte on a mango branch, and barnacles growing on the back of a whale benefit while neither the mango tree nor the whale derives any apparent benefit.
- The cattle egret and grazing cattle. The egret most of time remains closer to the cattle. Whenever cattle move it enables moving of vegetation and so the insects have to move out, which becomes the food of the cattle egret.
- Another example of commensalism is the interaction between sea anemone that has stinging tentacles and the clown fish that lives among them. The fish gets protection from predators which stay away from the stinging tentacles. The anemone does not appear to derive any benefit by hosting the clown fish.

Figure 13 orchid growing on a mango branch

Figure 14 barnacles growing on the back of a whale

Figure 13 Cattle egret and grazing cattle.

Figure 14 Sea anemone and the clown fish

Mutualism

+	+	Mutualism

- This interaction confers benefits on both the interacting species. Example –
- Lichens have mutual relationship between fungus and photosynthesizing algae or cyanobacteria. (want to know more about these terms click here)
- Mycorrhizae are associations between fungi and the roots of higher plants. 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.

THINK

- What is Symbiosis?

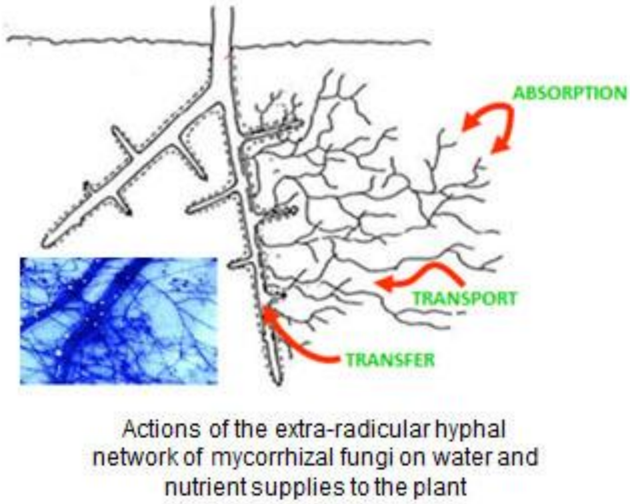


Figure 15 Mycorrhizae

- Example of pollination between plants and animal agent is most fascinating. Plants needs help of animals for pollination and dispersal of seeds. Animals are paid 'fees' for their service in form of pollen and nectar (to pollinators) and juicy and nutritious foods (to seed dispersers).

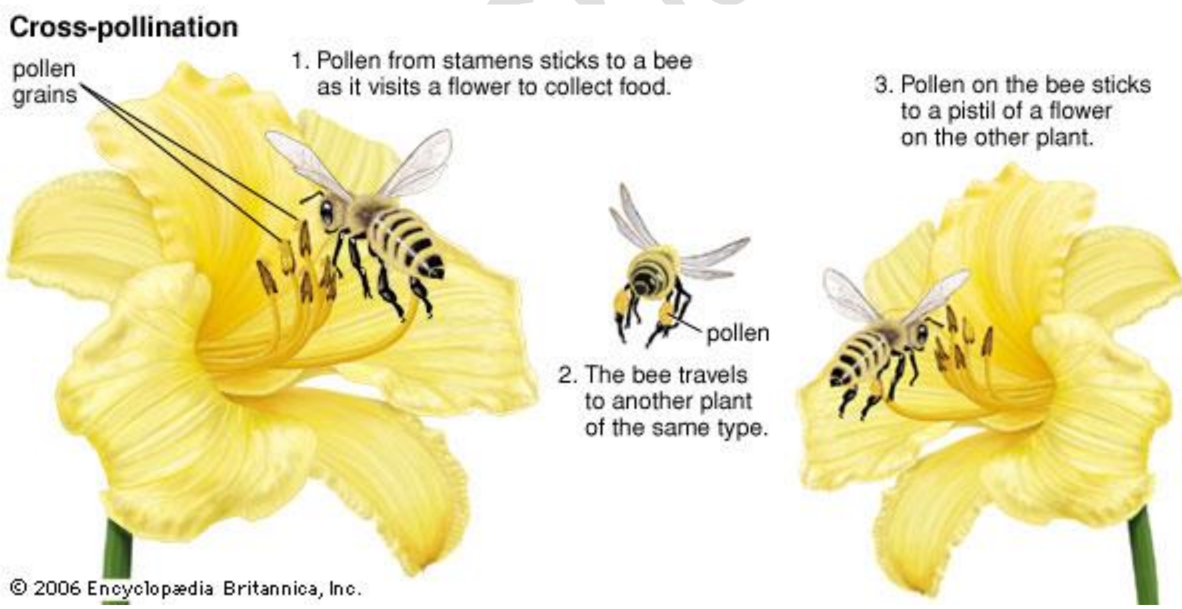


Figure 16 Pollination process

- But this mutually beneficial system must be safeguarded against cheaters. For example – Mediterranean orchid *Ophrys* employs 'sexual deceit' to get pollination done by a species of bee. One of the petals of flower bears similar size, markings and color of female bee. The male bee is attracted to it perceiving it as a female bee and tried to pseudocopulate. In this process bee is dusted with pollen from the flower and when this same bee pseudocopulate with other flower it transfers the pollen and thus, pollinates the flower

Ammensalism

-	0	Amensalism

- Amensalism is any relationship between organisms of different species in which one organism is inhibited or destroyed while the other organism remains unaffected.
- Organisms that secrete antibiotics and the species that get inhibited by the antibiotics are examples of amensalism.
- For example the bread mould fungi Pencillium produce penicillin an antibiotic substance which inhibits the growth of a variety of bacteria.
- Examples – click here (must watch)

Community

- An organism cannot survive without interacting with other organisms and so, we never see a plant or animal seldom occur by themselves.
- Example – Animals need plants as their food and plants need animals in pollination, seed dispersal, and soil microorganism for micronutrient supply and thus the two needs each other.
- Mostly communities are named after the dominant species. Example – grassland community is dominated by grasses, though it may contain herbs, shrubs and trees.
- Communities are not fixed or rigid. They can be small or large. Like human community is so large while tiger community is too small.

Types of community

On the size of community, we can classify the community as follows –

1. **Major community**
2. **Minor community**

Major community – these communities are –

- Large sized

- Well organized
- Independent
- They need not any input or output from any adjacent community. But they depend only on the Sun's energy.
- Example – Tropical evergreen forest

Minor community – unlike major community these communities are –

- Dependent on neighboring communities and so many times are also known as societies.
- They are dependent because they are secondary aggregations within a major community.
- Example – a mat of a lichen on a cow dung pad.

Structure of a Community

The structure of a community is its characteristics and that are determined by environmental factors.

Characteristics of community –

- Population
- Range
- Type of area inhabited by them
- Diversity of species

THINK!

- Adaptation
- Evolution
- Speciation
- Mutation
- Variation
- Natural Selection
- Extinction

Ecosystem

An ecosystem is a community of living organisms in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system.

Example -

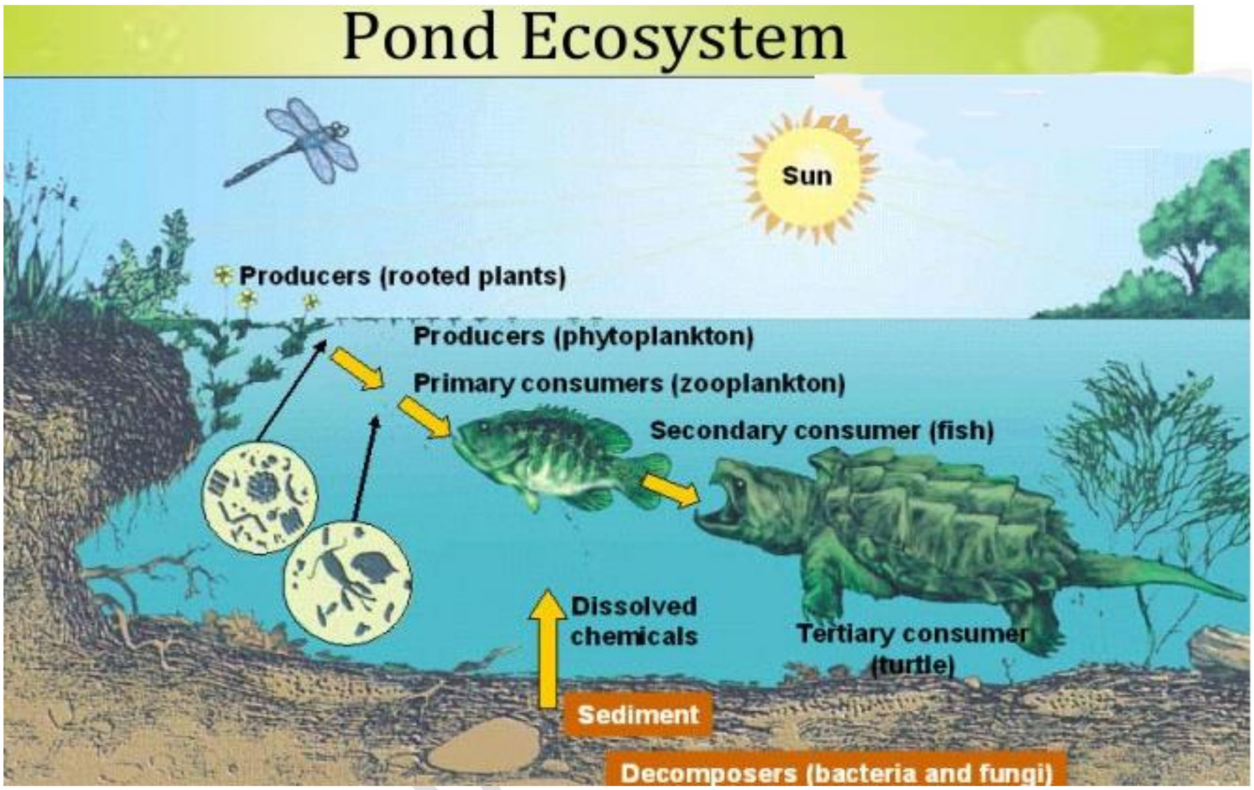


Figure 17 Pond ecosystem

- By this example we can understand the concept of ecosystem. It performs all the processes of an ecosystem i.e. productivity, decomposition, energy flow and nutrient recycling.
  - Abiotic component – water with dissolved organic and inorganic substances and rich soil deposit. Sunlight, temperature, day-length and other climatic conditions regulate the functioning of entire period.
  - Autotrophic components – Phytoplankton, algae, floating, submerged and marginal plants.
  - Consumers – zooplankton, free swimming and bottom dwelling forms.
  - Decomposers – fungi, bacteria and flagellates
  - This system also performs all the functions of any ecosystem and of a biosphere as a whole i.e. conversion of inorganic material into organic with the help of

energy of sun by autotrophs. Consumption of heterotrophs by autotrophs. Decomposition and mineralization of dead matter for nutrient recycling.

- It is a complex set of relationship among Living organisms, habitats and residents of an area.
- Ecosystems vary in sizes but functions of an ecosystem remain same. Example – pond ecosystem and ocean system vary in sizes but have same functions.
- If one part of an ecosystem damages it has impact on everything else.
- When an ecosystem is healthy all its elements are live in balance and are capable of reproducing itself.

THINK!

Which one of the following is the best description of the term "ecosystem"?

a) A community of organisms interacting with one another
b) That part of the Earth which is inhabited by living organisms
c) A community of organisms together with the environment in which they live.
d) The flora and fauna of a geographical area.

Solution- Find out?

Components of Ecosystem

1. Abiotic components

- These are inorganic and non-living things. It consists of soil, air water, light etc. Large no. of chemicals and physical processes like earthquake, volcanoes are also part of it.
- These components play a major role in deciding where and how an organism will live in its environment.

a) Energy

- It is necessary for maintenance of life. For plants sun is source of energy and since plants cannot use this energy from sun they eat plants and gets energy from themselves.

b) Rainfall

- Water is essential for all living organisms and especially for our body which consists of 70% water and helps in regulating temperature. It is also habitat for many organisms like fish, frog etc.

c) Temperature

- It is a very important factor in our environment. As you can see that they decide our climate, vegetation, even our body also tries to maintain constant body temperature.

d) Atmosphere

- It is also one of the factor which helps in survival of organism by important gases, protecting from sun's harmful rays etc. it is made up of - Nitrogen – 78%, Oxygen – 21%, CO_2 – 0.038% and inert gases (Argon - 0.39%, Neon etc.)

e) Substratum

- Land is covered by soil and a wide variety of microbes, protozoa, fungi and small animals (invertebrates) thrive in it. Roots of plants pierce through the soil to tap water and nutrients.
- Organisms can be terrestrial or aquatic. Terrestrial animals live on land. Aquatic plants, animals and microbes live in fresh water as well as in the sea. Some microbes live even in hot water vents under the sea.

f) Materials

- Inorganic compounds – carbon, carbon dioxide, nitrogen, water, nitrates, ion of various metals are necessary for survival of organisms.
- Organic compounds – proteins, carbohydrates, lipids, fats are made from decomposition of inorganic compounds.

g) Latitude and altitude

- Different climates like tropic, subtropical, tundra on earth are determined by latitude and other factors. And climate decides what kind of vegetation would be there.

2. Biotic components

- It consists of living organisms like plants, animals, microbes. They are classed into producers and consumers according to their functional attributes.

a) Primary producers – autotrophs (self –nourishing)

- These are basically green plants and certain bacteria and algae.
- They make their food (carbohydrate) on own by using carbon dioxide, water in the presence of sunlight. This process is called as photosynthesis.
- In terrestrial ecosystem – herbaceous and woody plants are producers.
- In aquatic ecosystem - various species of microscopic algae.

b) Consumers – Heterotrophs or phagotrophs

- They depend on others for food i.e. not capable of producing their own food.
- They can be divided into 2 broad categories – Macroco nsumers and Micro consumers.

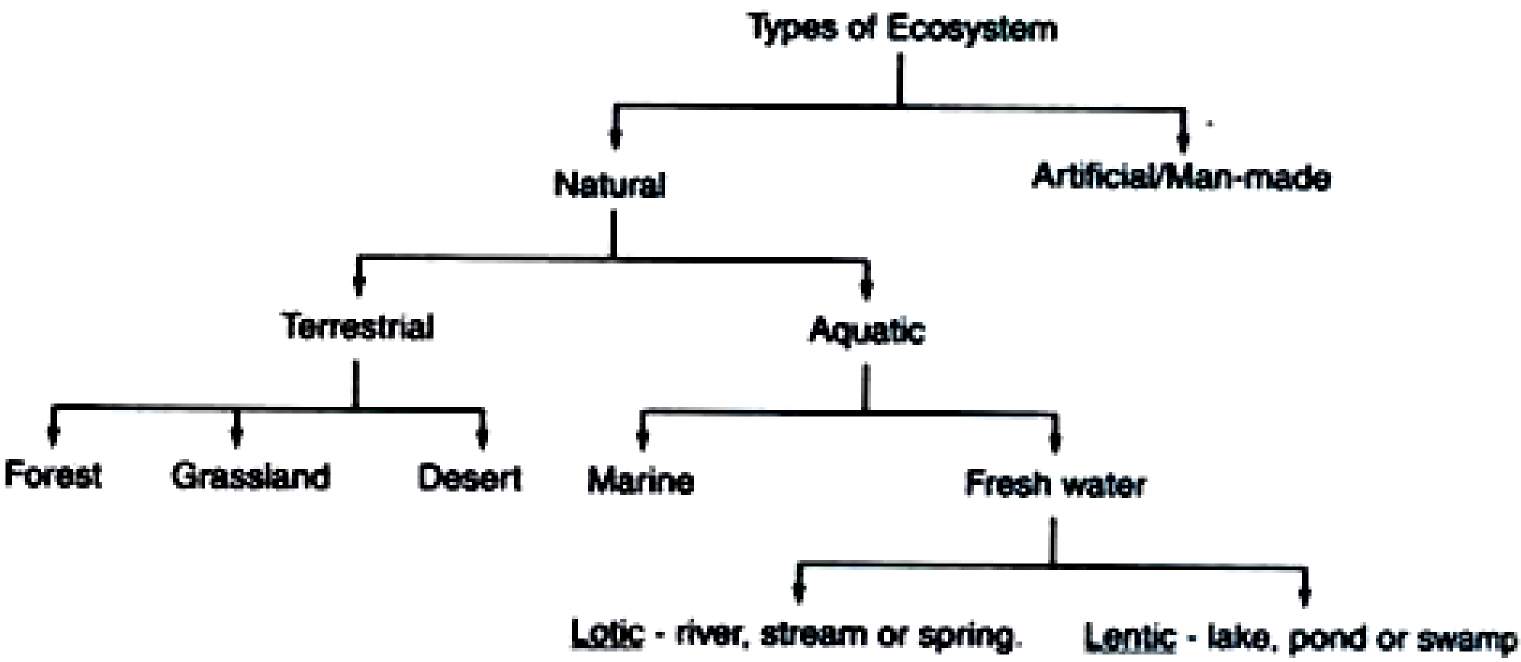
Macro consumers

- They feed on plants or animals or both.
- *Herbivores* are primary consumers which feed mainly on plants e.g. cow, rabbit.
- *Secondary consumers* feed on primary consumers e.g. wolves.
- *Carnivores* which feed on secondary consumers are called tertiary consumers e.g. lions which can eat wolves.
- *Omnivores* are organisms which consume both plants and animals e.g. man, crow, Bear etc.

Micro consumers – Saprotrophs (decomposers or osmotrophs)

- Detritivores (e.g., earthworm) break down detritus (dead organic substances) into smaller particles.
- The products of decomposition such as inorganic nutrients which are released in the ecosystem are reused by producers i.e. plants and thus recycled.
- Earthworm and certain soil organisms (such as nematodes, and arthropods) are detritus feeders and help in the decomposition of organic matter

Classification of Ecosystems



Goods and Services provided by Ecosystems

The Millennium Ecosystem Assessment found that 60% of ecosystem services are being degraded or used unsustainably

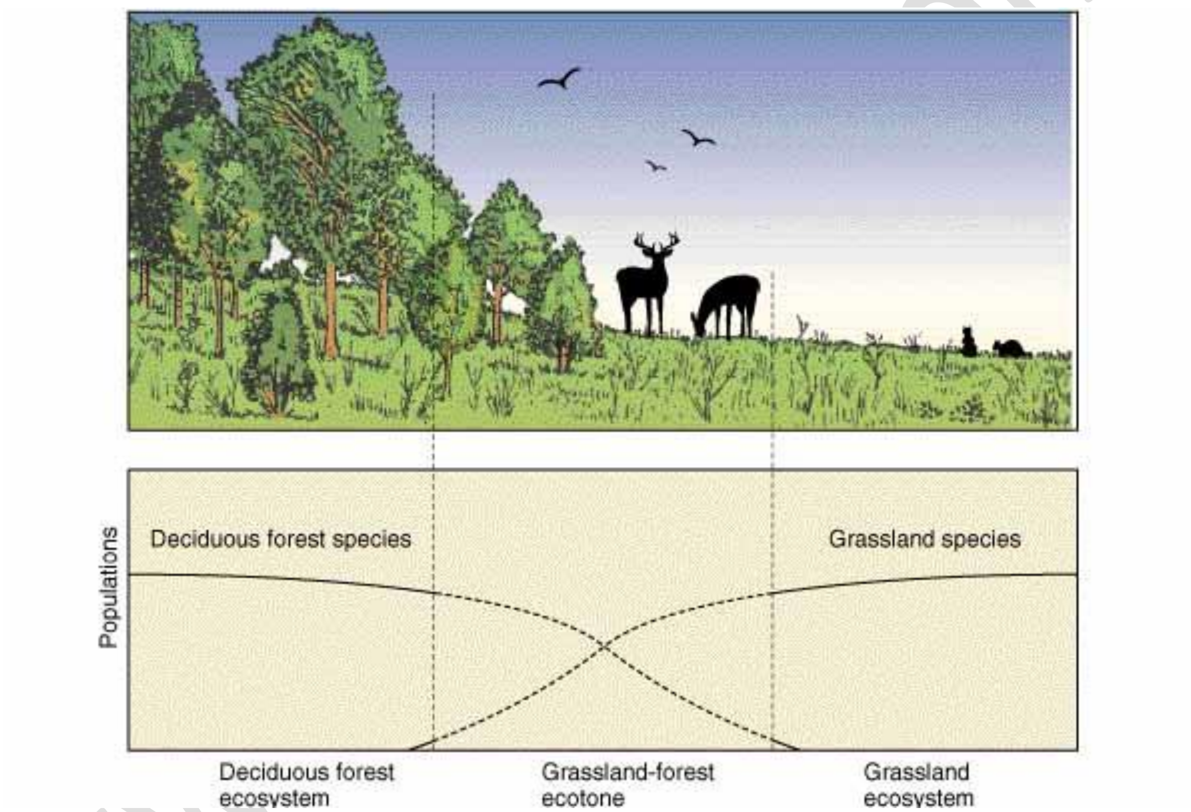
	Degraded	Mixed	Enhanced
Provisioning	• Capture fisheries • Wild foods • Biomass fuel • Genetic resources • Biochemicals, natural medicines, & pharmaceuticals • Freshwater	· Timber and wood fiber · Other fibers (e.g., cotton, hemp, silk)	· Crops · Livestock · Aquaculture
Regulating	• Air quality regulation • Regional & local climate regulation • Erosion regulation • Water purification & waste treatment • Pest regulation • Pollination • Natural hazard regulation	· Water regulation · Disease regulation	· Global climate regulation (carbon sequestration)
Cultural	• Spiritual, religious, or cultural heritage values • Aesthetic values	· Recreation & ecotourism	

Source: Millennium Ecosystem Assessment, 2005

Ecotone

- Ecotone is the place where two diverse ecosystems meet together.
- Example – meeting of pond ecosystem and terrestrial ecosystem.

Ecotone, a transitional area of vegetation between two different plant communities, such as forest and grassland. It has some of the characteristics of each bordering biological community and often contains species not found in the overlapping communities. An ecotone may exist along a broad belt or in a small pocket, such as a forest clearing, where two local communities blend together.



Characteristics of Ecotone

- It can be wide or narrow.
- Because it is intermediate zone of the 2 ecosystem. It is zone of tension.
- Usually, the number and the population density of the species of an outgoing community decreases as we move away from community or ecosystem.
- A well-developed ecotone contains some organisms which are entirely different from that of the adjoining communities.

Edge Effect

The edge effect is an ecological concept that describes how there is a greater diversity of life in the region where the edges two adjacent ecosystems overlap, such as land/water, or forest/grassland. At the edge of two overlapping ecosystems, you can find species from both of these ecosystems, as well as unique species that aren't found in either ecosystem but are specially adapted to the conditions of the transition zone between the two edges.

In the terrestrial ecosystems edge effect is especially applicable to birds. For example, the density of birds is greater in the mixed habitat of the ecotone between the forest and the desert.

For example - The Keoladeo Ghana national park forms an ecotone between the hilly forests of Aravalli's and the Thar Desert, which is situated in the northwest.

Figure 18 Keoladeo Ghana national park

THINK

Edge Species: Evolutionarily Distinct and Globally Endangered (EDGE) species have few close relatives and are often extremely distinct in the way they look, live and behave. These unique species are also on the verge of extinction, and if they disappear there will be nothing like them left on the planet. They represent a disproportionate amount of unique evolutionary history.

Ecological Niche

- The function or position of a species within an ecological community OR it is the role the species plays, and includes the type of food it eats, where it lives, where it reproduces, and its relationships with other species.

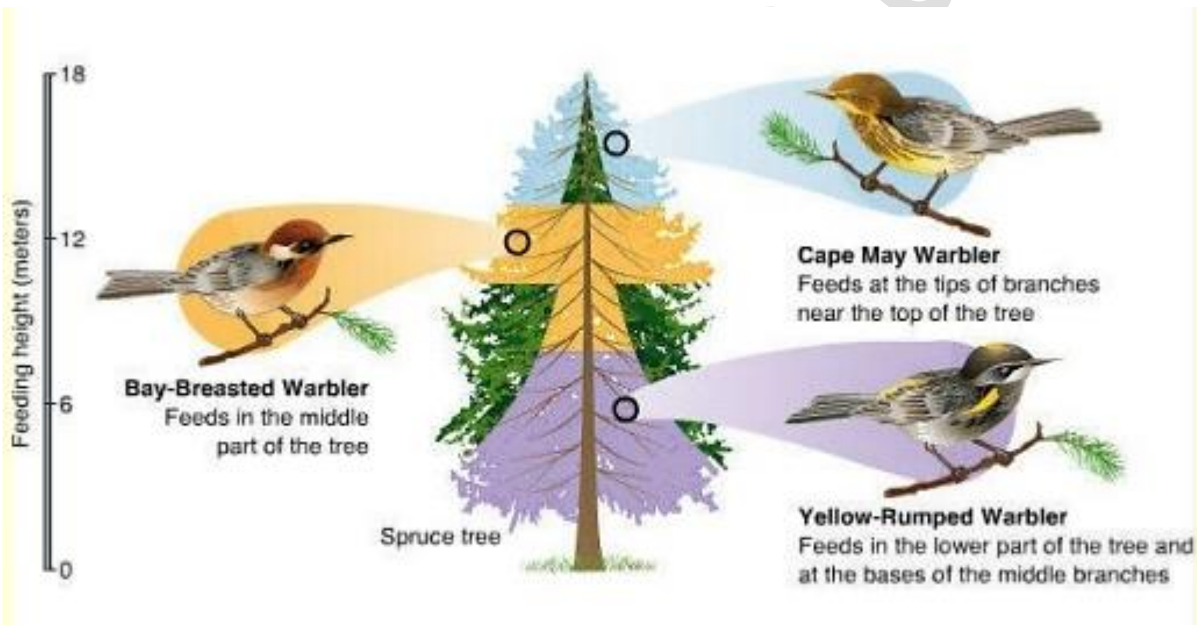
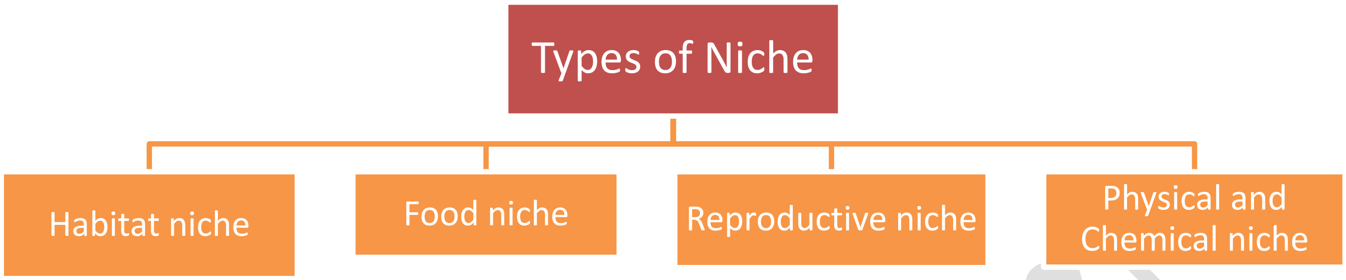


Figure 19 Niche example

- A species' niche includes the physical environment to which it has become adapted as well as its role as producer and consumer of food resources.
- A niche is unique for a species, which means no two species have exact identical niches. Niche plays an important role in conservation of organisms.
- If we have to conserve species in its native habitat we should have knowledge about the niche requirements of the species and should ensure that all requirements of its niche are fulfilled.

Types of Niches



1. **Habitat niche** - where it lives
2. **Food niche -** what is eats or decomposes & what species it competes with
3. **Reproductive niche**-how and when it reproduces.
4. **Physical & Chemical niche** - temperature, land shape, land slope, humidity & other requirement.

Difference between Niche and environment

Niche	Habitat
The role an organism plays in the environment (Its “job” in the community)	Place where an organism lives.

FUNCTIONS OF AN ECOSYSTEM

Energy Flow

- Energy flow, also called the **calorific flow,** refers to the flow of energy through a food chain.
- Energy flow is based on two important Laws of Thermodynamics.
- **The first law of Thermodynamics**: The amount of energy in the universe is constant. It may change from one form to another, but it can neither be created nor destroyed.
- Light energy can be neither created nor destroyed as it passes through the atmosphere. It may, however, be transformed into another type of energy, such as chemical energy or heat energy. These forms of energy cannot be transformed into electromagnetic radiation.
- **The second law of Thermodynamics:** The non-random energy (mechanical, chemical, radiant energy) cannot be changed without some degradation into heat energy. The change of energy from one form to another takes place in such a way that a part of energy assumes waste form (heat energy).
- In this way, after transformation the capacity of energy to perform work is decreased. Thus, energy flows from higher to lower level.
- Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth.

Energy flow in Ecosystems:

- Living organisms can use energy in two forms radiant and fixed energy.
- **Radiant energy** is in the form of electromagnetic waves, such as light.
- **Fixed energy** is potential chemical energy bound in various organic substances which can be broken down in order to release their energy content.
- **Autotrophs** - Organisms that can fix radiant energy utilizing inorganic substances to produce organic molecules.
- **Heterotrophs** - Organisms that cannot obtain energy from abiotic source but depend on energy-rich organic molecules synthesized by autotrophs.
- **Consumers** - Those which obtain energy from living organisms are called consumers.
- **Decomposers -** Those which obtain energy from dead organisms are called decomposers.

Flow of Energy at different Levels of Ecosystem

- **Photosynthetically Active Radiation** (PAR) is the amount of light available for **photosynthesis**, which is light in the 400 to 700 nanometre wavelength range. Of the incident solar radiation less than 50 per cent of it is Photosynthetically Active Radiation (PAR).
- Plants and photosynthetic bacteria (autotrophs), fix suns' radiant energy to make food from simple inorganic materials. Plants capture only 2-10 per cent of the PAR and this small amount of energy sustains the entire living world.
- When the light energy falls on the green surfaces of plants, a part of it is transformed into chemical energy which is stored in various organic products in the plants.
- When the herbivores consume plants as food and convert chemical energy accumulated in plant products into kinetic energy, degradation of energy will occur through its conversion into heat.
- When herbivores are consumed by carnivores of the first order (secondary consumers) further degradation will occur.
- Similarly, when primary carnivores are consumed by top carnivores, again energy will be degraded.
-

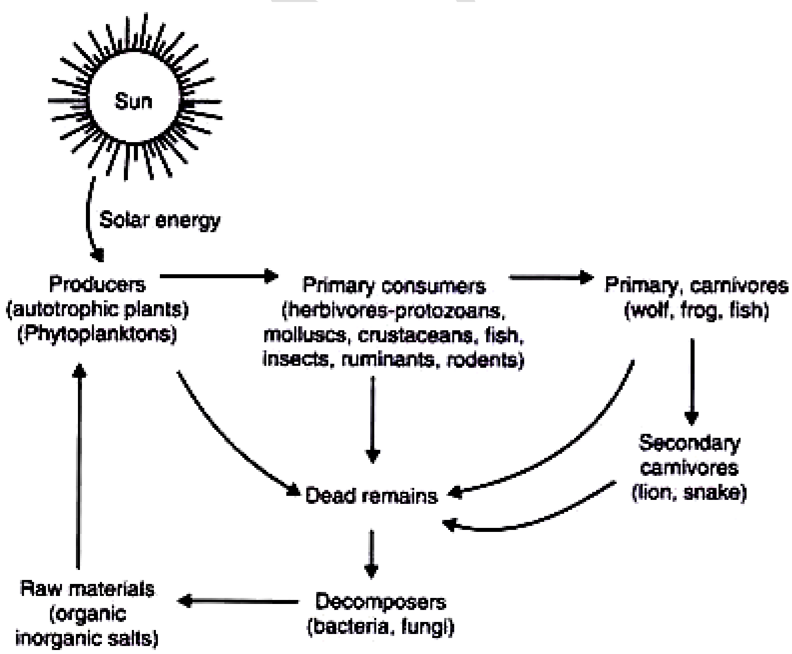


Fig. 3.7. Flow of energy at different levels of ecosystem.

- **Trophic level -** The producers and consumers in ecosystem can be arranged into several feeding groups, each known as trophic level (feeding level).

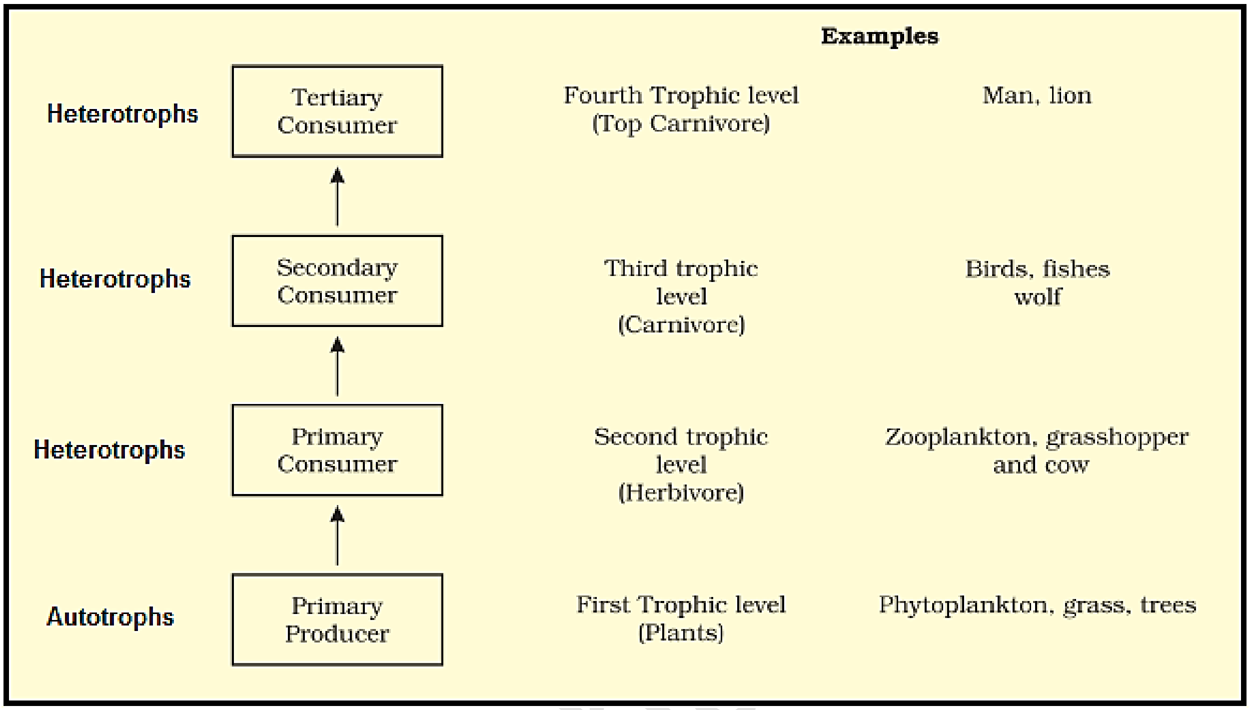


Figure 20 Diagrammatic representation of trophic levels in an ecosystem

Food Chain

- **Food chain** - It may be defined as the transfer of energy and nutrients through a succession of organisms through repeated process of eating and being eaten.
- A food chain starts with producers and ends with top carnivores.
- For example, marsh grass is consumed by grasshopper, the grasshopper is consumed by a bird and that bird is consumed by hawk.
- Thus, a food chain is formed which can be written as follows:
- Marsh grass ----→ grasshopper ----→ bird → hawk

Detailed explanation

- In the ecosystem, green plants alone are able to trap in solar energy and convert it into chemical energy. The chemical energy is locked up in the various organic compounds, such as carbohydrates, fats and proteins, present in the green plants.

- Since virtually all other living organisms depend upon green plants for their energy, the efficiency of plants in any given area in capturing solar energy sets the upper limit to long-term energy flow and biological activity in the community.
- Plants themselves and herbivores use food manufactured by green plants.
- Herbivores fall prey to some carnivorous animals.
- In this way one form of life supports the other form. Thus, food from one trophic level reaches to the other trophic level and in this way a chain is established. This is known as **food chain.**

Types of food chain

Food chains are of three types -

1. Grazing food chain
2. Parasitic food chain
3. Saprophytic or detritus food chain

1. Grazing Food Chain (GFC)

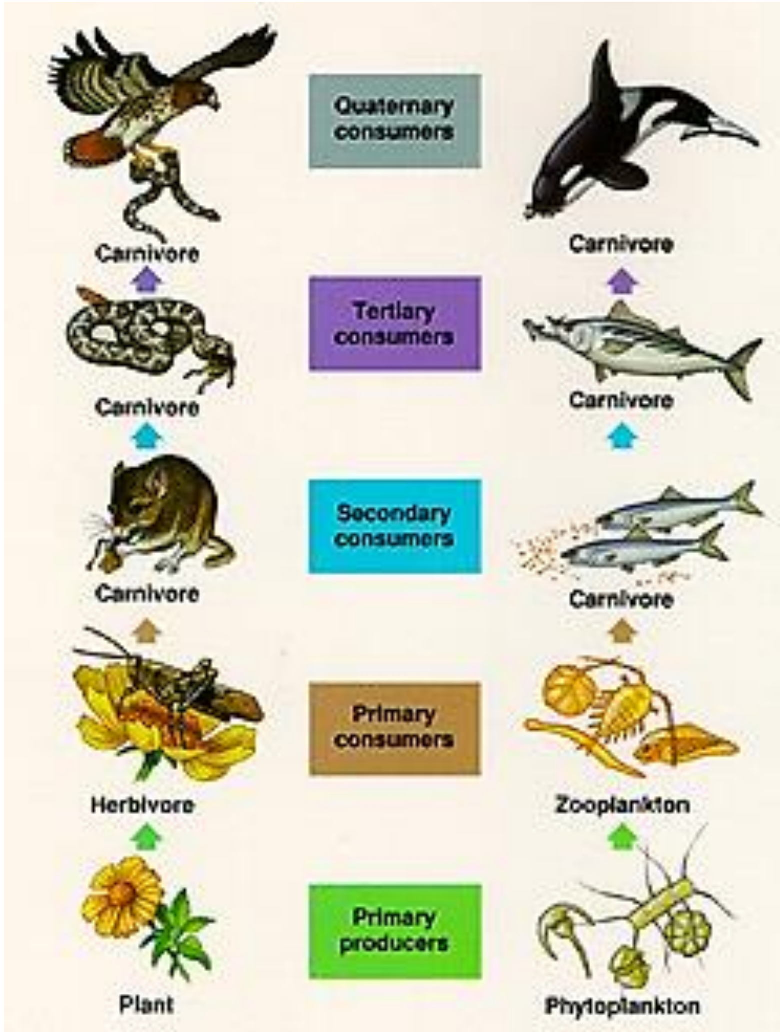


Figure 21 Grazing food chain with Terrestrial ecosystem in left and Aquatic ecosystem in right

- **Grazing food chain** starts with green plants which are the producers. The green plants or producers are grazed by herbivorous animals which are further eaten by carnivores.

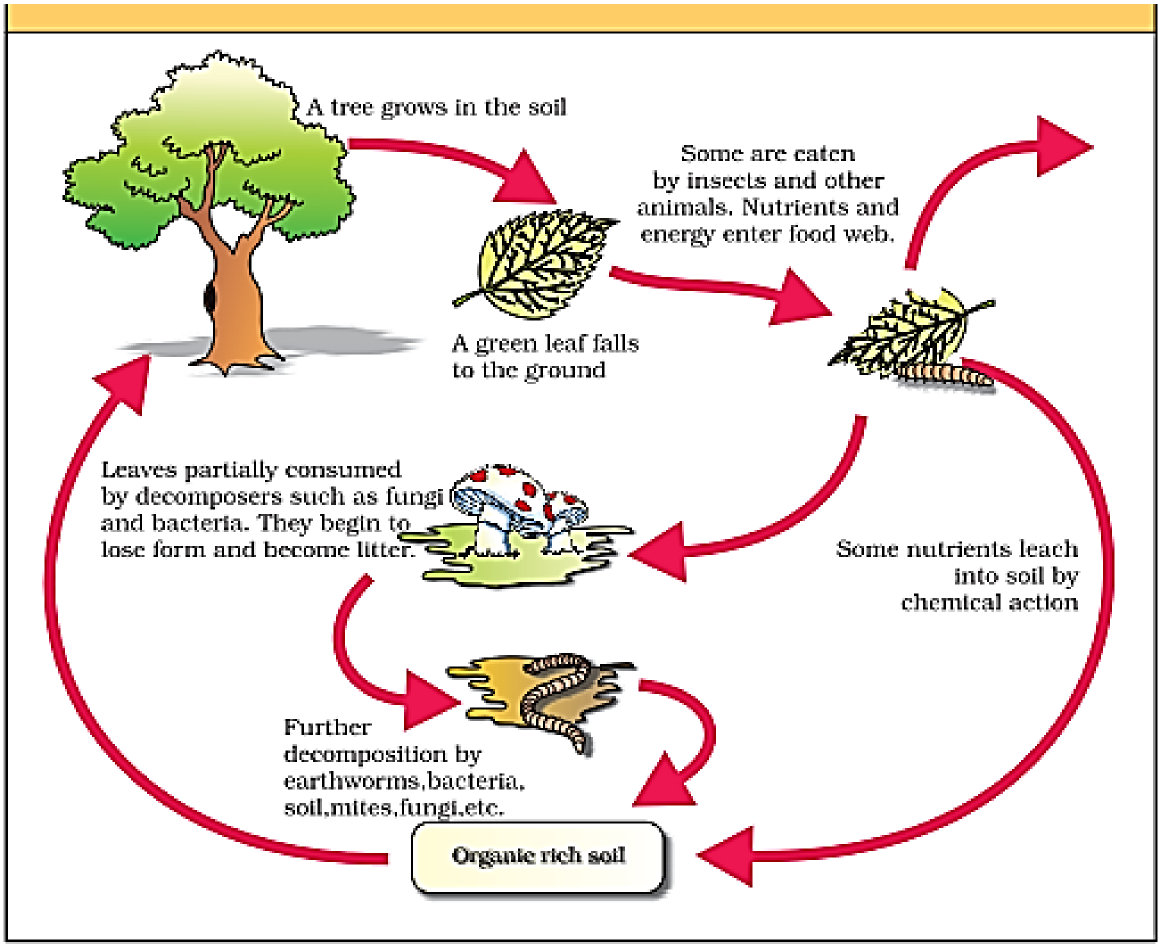


Figure 14.1 Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

- Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as **catabolism**.
- Humification and mineralization occur during decomposition in the soil.
- **Humification** leads to accumulation of a dark colored amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate.
- Being colloidal in nature, humus serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occurs by the process known as **mineralization**.
- *Warm and moist environment favor decomposition whereas low temperature and anaerobiosis inhibit decomposition* resulting in buildup of organic materials.
- Example - Primary producers (Autotrophs)-> Primary consumers (Herbivores)-> Secondary Consumers (Carnivores)
- The chain begins with green plants (producers) at the first trophic level.
- Energy for this food chain comes from the sun.

- Food chain adds energy into the ecosystem.
- The food chain fixes inorganic nutrients.
- It consists of all macroscopic organisms.
- For example, in terrestrial ecosystem, grass is eaten by caterpillar, which is eaten by lizard and lizard is eaten by snake.
- In Aquatic ecosystem phytoplankton (primary producers) are eaten by zoo planktons which are eaten by fishes and fishes are eaten by pelicans.

2. Parasitic food chain

- If in the food chain, the primary and other levels of consumers are parasitic, then the food chain is described as parasitic food chain.

- For example – Birds → Bird lice → Protozoan

3. Detritus food chain (DFC)

- This type of food chain starts from dead organic matter of decaying animals and plant bodies.
- Dead organic matter or detritus feeding organisms are called **detrivores** or **decomposer**. The detrivores are eaten by predators.

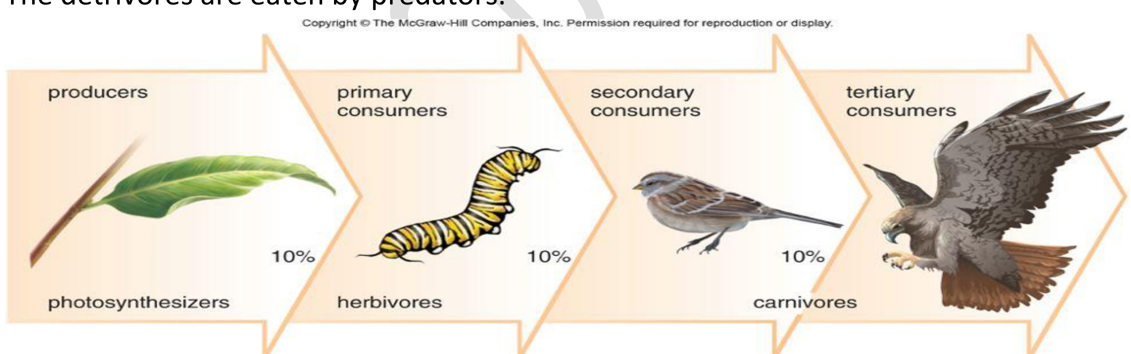


Figure 22 Detritus food chain

- It is made up of **decomposers** which are heterotrophic organisms, mainly fungi and bacteria.
- Energy for this food chain comes from remains of detritus.
- Decomposers are also known as **saprotrophs** (*sapro: to decompose*).
- Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.
- In terrestrial ecosystem larger fraction of energy flows through the detritus food chain than through the GFC. While it is opposite in aquatic ecosystem.

- This food chain takes up energy from the detritus, ensuring maximum utilization and minimum wastage.
- The food chain helps in fixing inorganic nutrients.
- It consists of sub soil organisms.
- GFC and DFC are linked.

Food Web

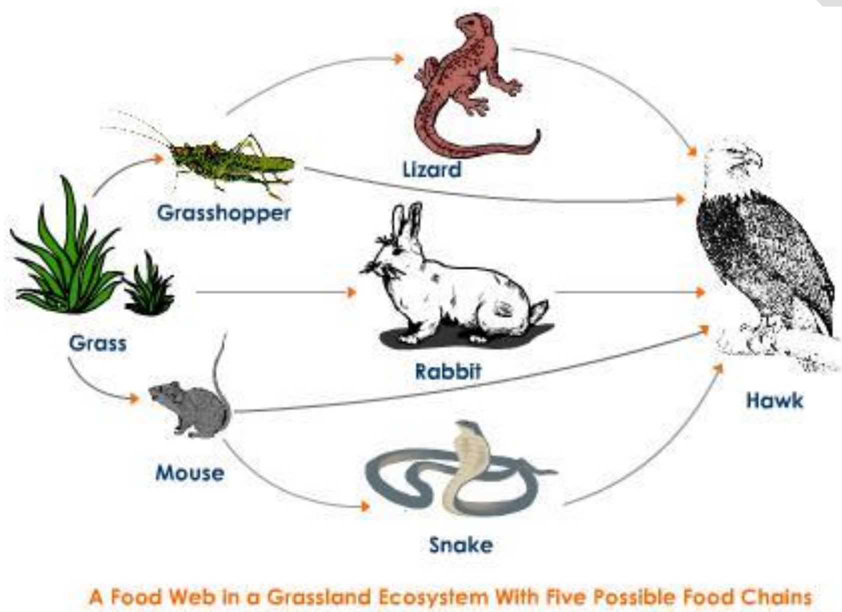


Figure 23 food web

- A **food web** (or **food** cycle) is the natural interconnection of **food chains** and generally a graphical representation (usually an image) of what-eats-what in an ecological community.
- Another name for **food web** is a consumer-resource system.
- An ecosystem may consist of several interrelated food chains.
- The same food resource is part of more than one chain, especially when that resource is at the lower trophic levels.
- If a keystone species is removed, then not only the succeeding links of the chain will be affected but also whole ecosystem is affected.
- The food web provides more than one alternative for food to most of the organisms in an ecosystem and therefore increases their chance of survival.
- For example, grasses may serve food for rabbit or grasshopper or goat or cow. Similarly a herbivore may be food source for many different carnivorous species.

- Food availability and preferences of food of the organisms may shift seasonally e.g. we eat watermelon in summer and peaches in the winter.
- Thus there are interconnected networks of feeding relations that take the form of food webs.

THINK

With reference to food chains in ecosystems, consider the following statements:

1. A food chain illustrates the order in which a chain of organisms feed upon each other.
2. Food chains are found within the populations of a species.
3. A food chain illustrates the numbers of each organism which are eaten by others.

Which of the statements given above is / are correct?

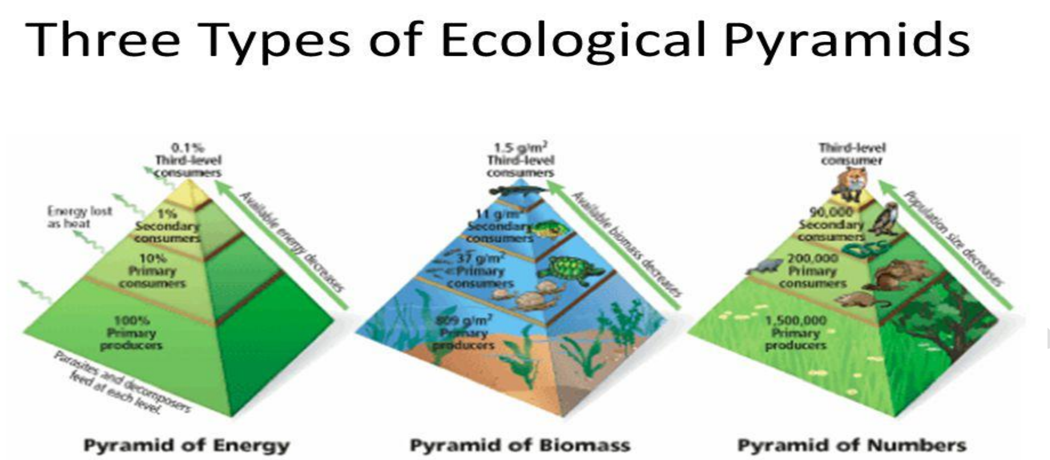
a) 1 only
b) 1 and 2 only
c) 1, 2 and 3
d) None

Solution: Find out?

Ecological Pyramids

- A pyramid-shaped diagram representing quantitatively the numbers of organisms, energy relationships, and biomass of an ecosystem.
- Numbers are high for the lowest trophic levels (plants) and low for the highest trophic level (carnivores).
- The pyramid consists of a number of horizontal bars depicting specific trophic levels which are arranged sequentially from primary producer level through herbivore, carnivore onwards.
- The length of each bar represents the total number of individuals at each trophic level in an ecosystem.

There are three types of Ecological pyramid –

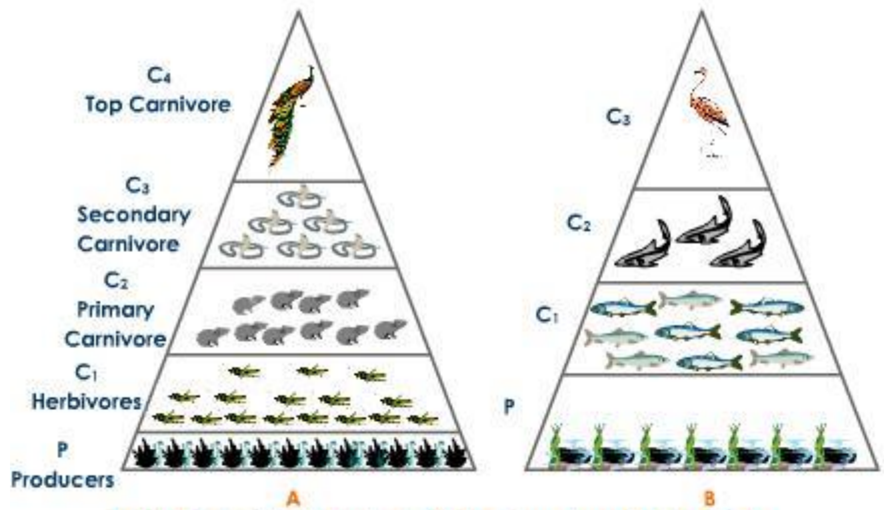


Pyramid of Numbers

- This deals with the relationship between the numbers of primary producers and consumers of different levels.
- It is a graphic representation of the total number of individuals of different species, belonging to each trophic level in an ecosystem.
- Depending upon the size and biomass, the pyramid of numbers may not always be upright, and may even be completely inverted.

a) Pyramid of Numbers – Upright

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

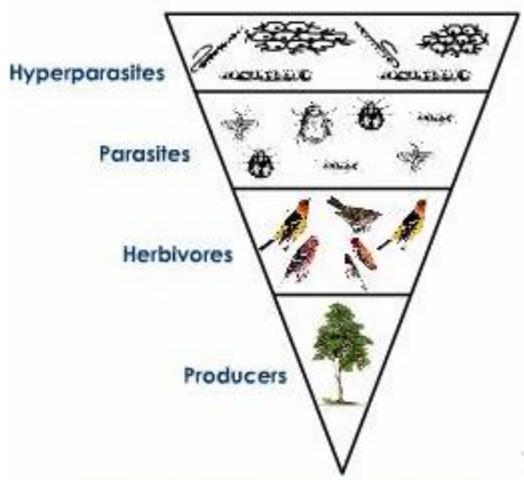


Upright Pyramids of Numbers. (A) In a Grass Land (B) In a Pond

- Lowest trophic level occupied by snails because of their abundance.
- Next higher trophic level – primary consumer – herbivore (example – Small fishes)
- Number of small fishes is less than that of snails.
- The next energy level is primary carnivore (example bigger fishes).
- The numbers of bigger fishes are less than small fishes because, they feed on smaller fishes.
- The next higher trophic level is secondary carnivore (example- Crane). They feed on bigger fishes.
- With each higher trophic level, the number of individual decreases.

b) Pyramid of Numbers – Inverted

- In this pyramid, the number of individuals is increased from lower level to higher trophic level.
- Example of this pyramid – A tree in forest ecosystem.



Inverted pyramid of number

- In the above diagram you can see that a big tree (primary producer) supports many birds (herbivores).
- These birds eat lots of tapeworms, fleas, and barnacles (parasites) which live on this tree. Number of parasites is more than number of birds.
- These parasites eat hyperparasites. Number of hyperparasites is greater than number of parasites.
- With each higher trophic level, the number of individual increases and so the resulting pyramid is of inverted shape.
- A pyramid of numbers does not take into account the fact that the size of organisms being counted in each trophic level can vary.
- It is difficult to count number of trees, birds and grasses etc. so the pyramid of no. doesn't completely define the trophic structure of ecosystem.

Pyramid of Biomass

- This pyramid overcomes the shortcomings of pyramid of numbers (size difference problem)

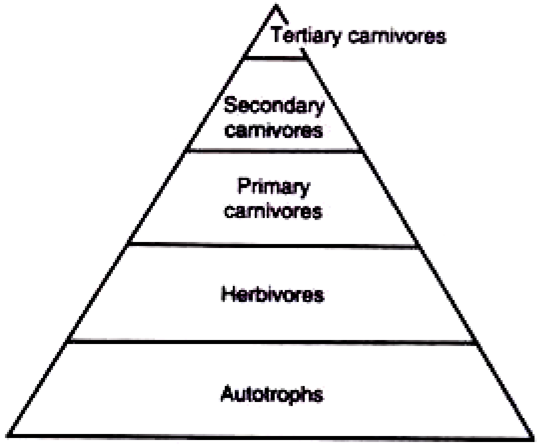


Fig. 3.13. A pyramid of biomass

- It weighs the organism of each trophic level instead of counting.
- It gives us the total dry weight of all organism at each trophic level.
- Biomass is measured in g/m^2.

a) Upward pyramid

- It also has large base of primary producers with smaller trophic level at top.

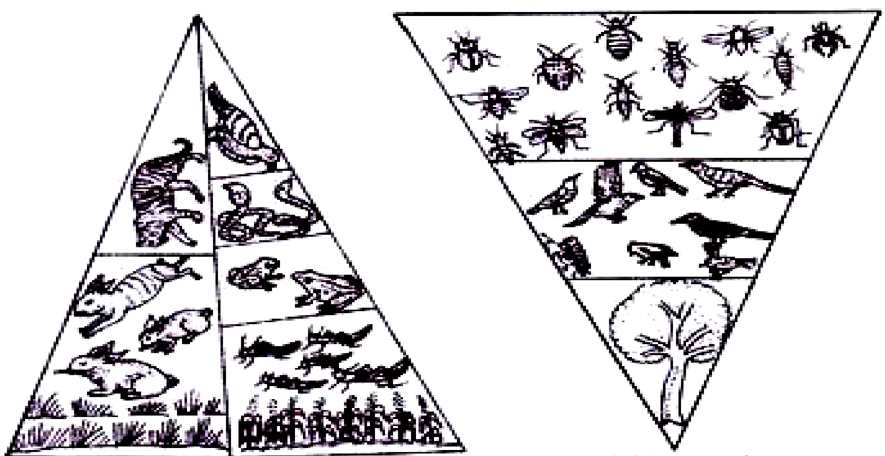
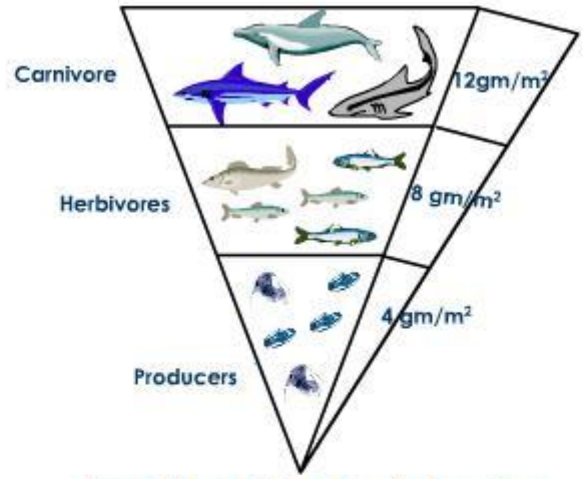


Fig. 3.14. (a & b). Pyramids of biomass
(a) A grassland ecosystems showing upright-triangular
(b) Inverted pyramid of biomass of an aquatic ecosystem.

- Producer's biomass is maximum.
- Next trophic level biomass – i.e. primary producer's biomass is less than the primary consumers and same is true for subsequent higher levels.
- The top trophic level has very less amount of biomass.

b) Inverted pyramid

- This kind of pyramid is found in many aquatic ecosystems.



Inverted Pyramid in an Aquatic Ecosystem

- Reason – producers are tiny phytoplanktons that grow and reproduce rapidly.
- The base of the pyramid is small while the top is larger showing biomass is increasing from bottom to top and so pyramid assumes inverted shape.

Pyramid of Energy

- Most suitable pyramid.
- Reflects the law of thermodynamics as it reflects the conversion of solar energy into chemical energy and heat energy (lost) at each trophic level.
- This is the reason that it is **always upward** (large energy base at bottom) and no inversion.

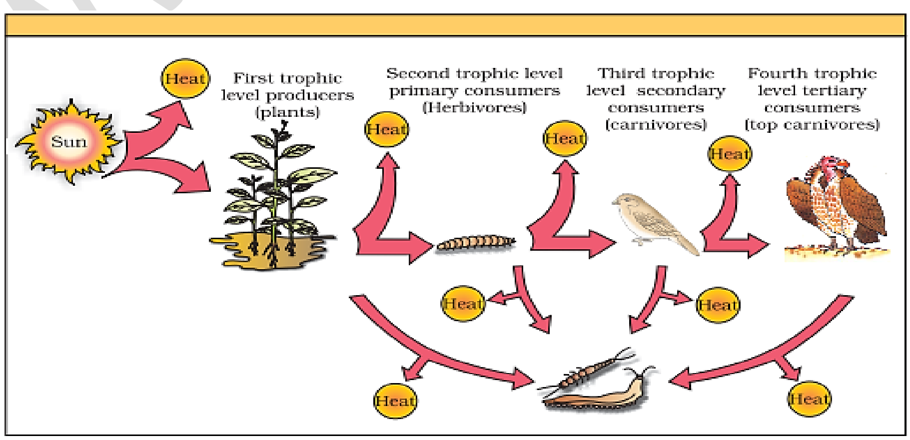
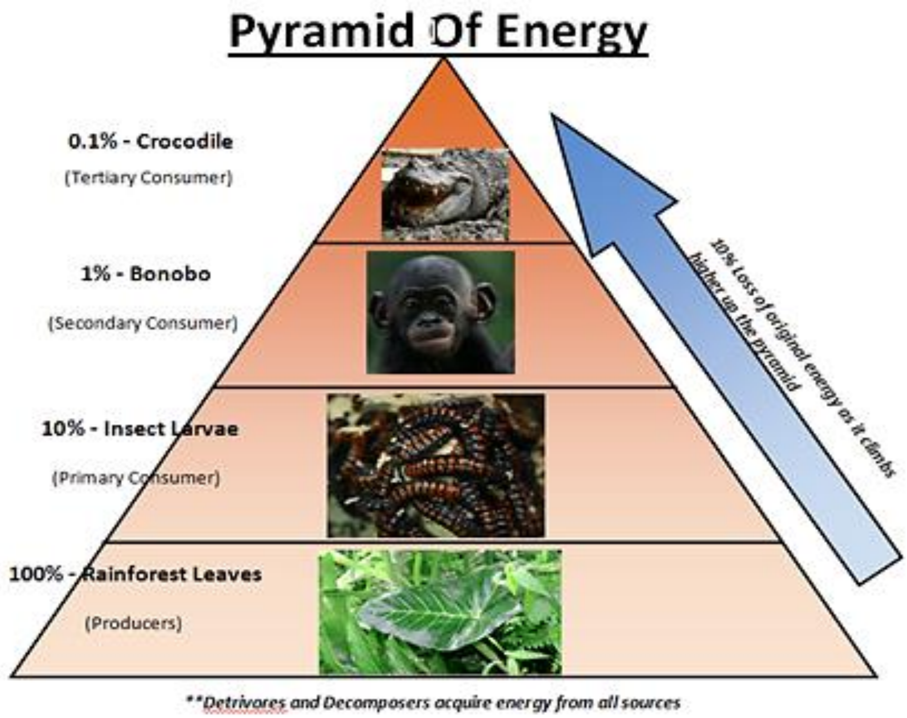


Figure 24 Conversion of Sunlight energy into chemical energy and heat energy



- For example – if sun light has 1 lakh joule energy and grasses or trees of a forest utilized part of this energy and made their food.
- The grasses or forest has 10000 joule energy.
- Deer receives only 1000 joule energy after eating the grasses because remaining energy is used by its body for respiration and other activities.
- Lion, who had eaten the deer, receives only 100 joule energy because of the same reasons mentioned above.
- In all the pyramids energy moves only in one direction i.e. unidirectional flow of energy. It never travels from producer to sun.
- **10% law** - According to this **law**, during the transfer of energy from organic **food** from one trophic level to the next, only about ten percent of the energy from organic matter is stored as flesh. The remaining is lost during transfer, broken down in respiration, or lost to incomplete digestion by higher trophic level.
- Energy pyramid concept helps to explain the phenomenon of biological magnification the tendency for toxic substances to increase in concentration progressively at higher levels of the food chain.

Pollutants and Trophic level

- **Pollutants** are substances that pollute the environment, especially gases from vehicles and poisonous chemicals produced as waste by industrial processes.
- Non-degradable pollutants move from one trophic level to another in an ecosystem.
- Non-degradable pollutants mean those which cannot be decomposed by living organisms.
- Example - **Chlorinated Hydrocarbons (CHC), Diclofenac.**
- **Chlorinated Hydrocarbons** or **Organochloride** or CHC are hydrocarbons whose some or most hydrogen atoms have been replaced by **chlorine** atoms. E.g. **DDT, endosulfan etc.**).
- A variety of simple chlorinated hydrocarbons including **dichloromethane, chloroform,** and **carbon tetrachloride.**

Applications of CHC

- Production of vinyl chloride almost all of which was converted into polyvinylchloride (PVC) [PVC pipes].
- **Chloroform, dichloromethane, dichloroethene, and trichloroethane** are useful solvents. These solvents are immiscible with water and effective in cleaning applications such as degreasing and dry cleaning.
- Pesticides and insecticides such as **DDT**, **heptachlor**, **and endosulfan** are CHCs.

Effects of CHC

- Dioxins (highly toxic organic compound produced as a by-product in some manufacturing processes), produced when organic matter is burned in the presence of chlorine, and some insecticides, such as DDT, are persistent organic pollutants.
- DDT, which was widely used to control insects in the mid-20th century, accumulates in food chains, and causes reproductive problems (e.g., eggshell thinning) in certain bird species.
- DDT residues continue to be found in humans and mammals across the planet many years after production and use have been limited.
- In Arctic areas, particularly high levels are found in marine mammals. These chemicals concentrate in mammals, and are even found in human breast milk.
- In some species of marine mammals, particularly those that produce milk with a high fat content, males typically have far higher levels, as females reduce their concentration by transfer to their offspring through lactation.

- Endosulfan, an agrichemical has acute toxicity, potential for bioaccumulation, and is a **endocrine disruptor** (enhances the effect of estrogens causing reproductive and developmental damage in both animals and humans).
- Because of its threats to human health and the environment, a global ban on the manufacture and use of endosulfan was negotiated under the **Stockholm Convention** in April 2011.

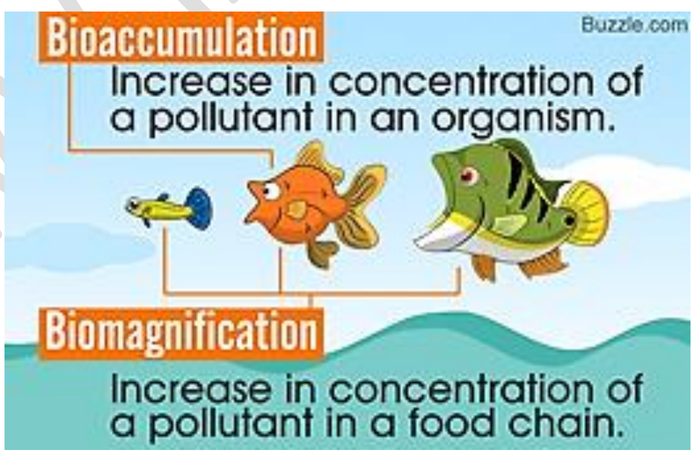
Movement of these pollutants involves two main processes:

1. Bioaccumulation
2. Bio magnification

Bioaccumulation

An important process through which chemicals can affect living organisms is bioaccumulation. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted. Understanding the dynamic process of bioaccumulation is very important in protecting human beings and other organisms from the adverse effects of chemical exposure, and it has become a critical consideration in the regulation of chemicals.

- It is defined as increase in concentration of a substance in an organism or a part of organism.
- Example – DDT, mercury, lead



Biomagnification

- It also accumulates pollutant but not in organism but in food chain.
- It is also called as bioamplification.
- Example - POPs (persistent organic pollutant) - chemical substances that persists in environment, bioaccumulates and have adverse impacts on all living organisms. E.g. of POPs Pesticide(DDT), industrial chemicals and industrial processes (dioxin and furans)

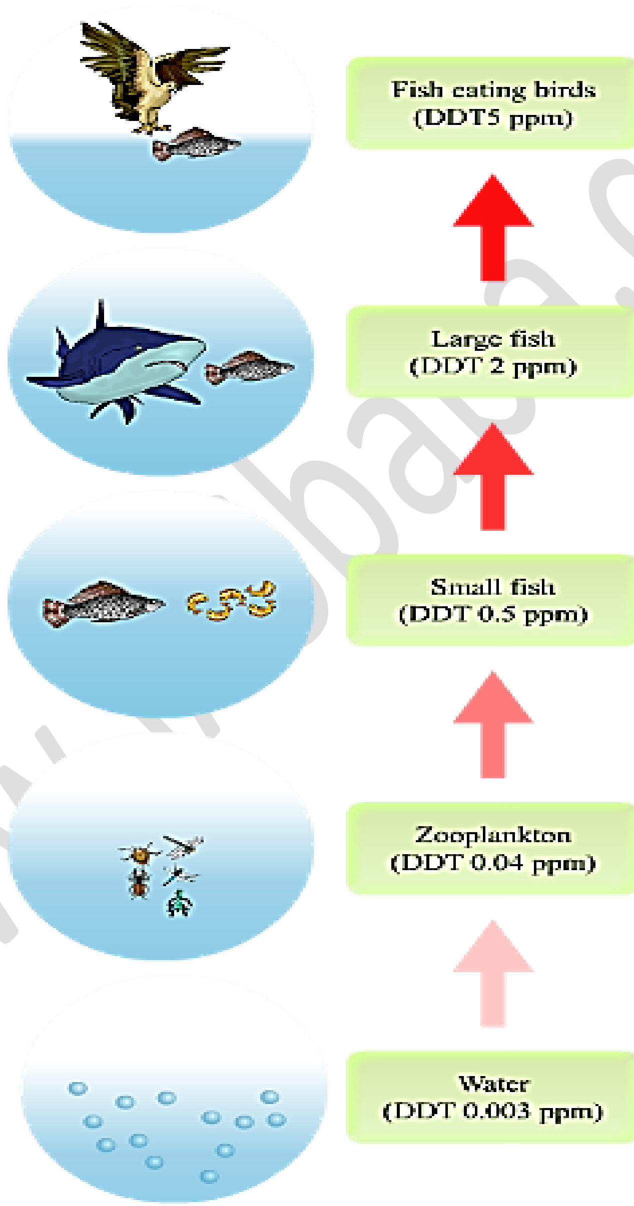


Figure 25 Biomagnification in an Aquatic food chain

- In order for biomagnification to occur, the pollutant must be: <u>long-lived, mobile, soluble in fats, biologically active</u>. E.g. DDT.

- If a pollutant is **short-lived**, it will be broken down before it can become dangerous.
- If it is not **mobile**, it will stay in one place and is unlikely to be taken up by organisms.
- If the pollutant is **soluble in water**, it will be excreted by the organism. Pollutants that **dissolve in fats**, however, may be retained for a long time.
- It is traditional to measure the amount of pollutants in fatty tissues of organisms such as fish.
- In mammals, we often test the milk produced by females, since the milk has a lot of fat in it and is often more susceptible to damage from toxins (poisons).

Functions of an Ecosystem

- The functions of an ecosystem include
  - Energy flow through food chain [Click here]
  - Nutrient cycling (biogeochemical cycles) [Click here]
  - Ecological succession [Click here]

Biogeochemical Cycles

- Energy flow and nutrient circulation are the major functions of the ecosystem.
- Energy is lost as heat forever in terms of the usefulness of the system. On the other hand, nutrients of food matter never get used up and recycle again and again indefinitely.
- **Carbon, hydrogen, oxygen, nitrogen** and **phosphorus** as elements and compounds make up 97% of the mass of our bodies and are more than 95% of the mass of all living organisms.
- In addition to these, about 15 to 25 other elements are needed in some form for the survival and good health of plants and animals.
- These elements or mineral nutrients are always in circulation moving from non-living to living and then back to the non-living components of the ecosystem in a more or less circular fashion. This circular fashion is known as **biogeochemical cycling** (bio for living; geo for atmosphere).
- Among the most important nutrient cycles are the carbon nutrient cycle and the nitrogen nutrient cycle.
- There are many other nutrient cycles that are important in ecology, including a large number of trace mineral nutrient cycles.

Nutrient Cycling

- The movement of nutrient elements through the various components of an ecosystem is called nutrient cycling.

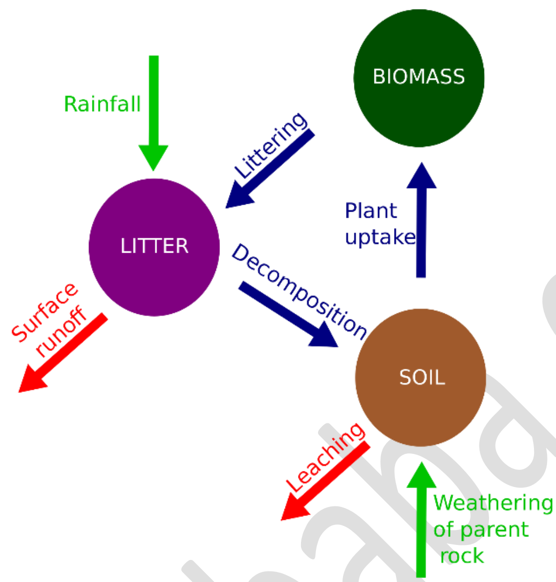


Figure 26 Nutrient cycle

- Another name of nutrient cycling is biogeochemical cycles (bio: living organism, geo: rocks, air, and water).
- Nutrient cycles are of two types: (a) gaseous and (b) sedimentary.
- Environmental factors, e.g., soil, moisture, pH, temperature etc., regulate the rate of release of nutrients into the atmosphere.
- Movement of nutrients from the environment into plants and animals and again back to the environment is essential for life and it is the vital function of the ecology of any region.
- Among the most important nutrient cycles are the carbon nutrient cycle and the nitrogen nutrient cycle. Both of these cycles make up an essential part of the overall soil nutrient cycle.

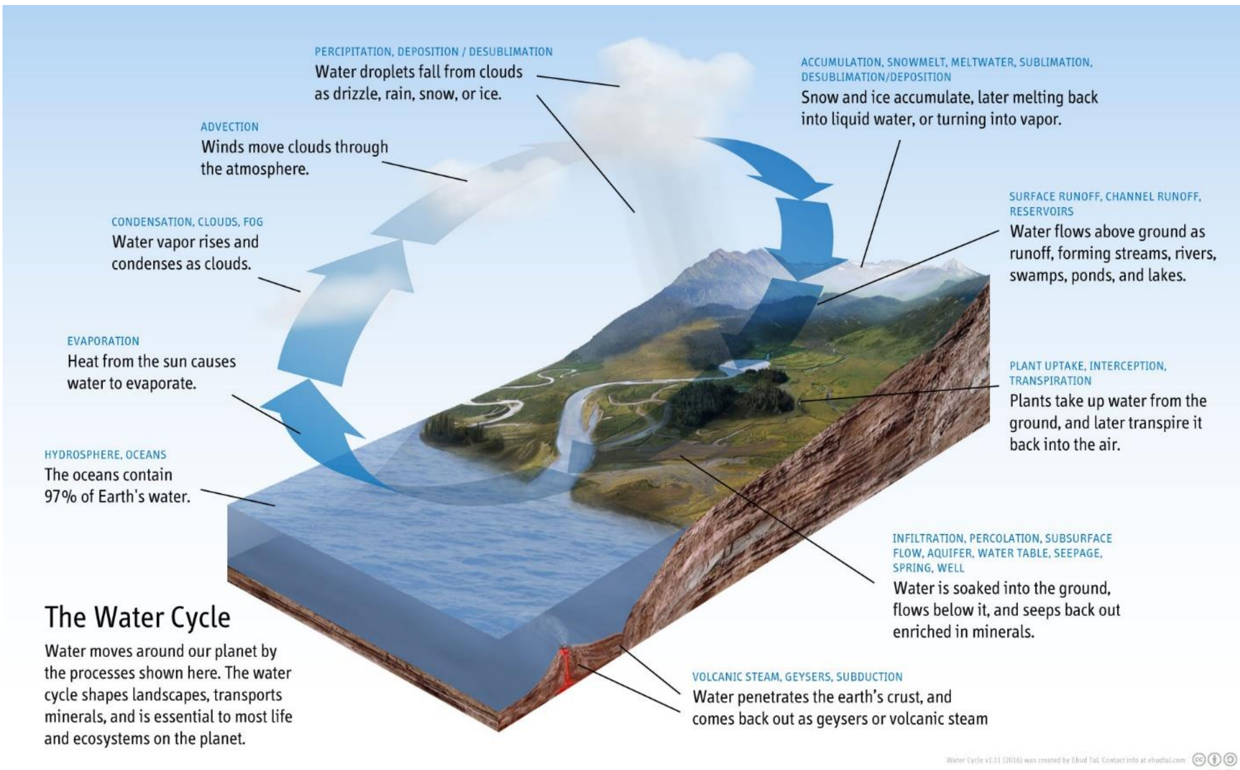
Gaseous Cycle

- The reservoir for gaseous type of nutrient cycle (e.g., nitrogen, carbon cycle) exists in the atmosphere.

- Most important gaseous cycles are - water, carbon and nitrogen.

Water cycle (Hydrologic)

- All of we know the importance of water. But water also plays important role in transportation of nutrients in nutrient cycle and acts as a solvent medium for uptake of nutrients by organisms.



Higher resolution – [Click here]

Carbon cycle

- Carbon is a minor constituent (0.038%) of the atmosphere as compared to oxygen (21%) and nitrogen (78%) and argon (0.9%).
- Without carbon dioxide life is not possible because it is vital for the production of carbohydrates through photosynthesis by plants.
- It is the element that anchors all organic substances from coal and oil to DNA (*deoxyribonucleic acid: the compound that carries genetic information*).
- Carbon is present in the atmosphere, mainly in the form of carbon dioxide (CO2).
- In the composition of living organisms, carbon constitutes 49 per cent of dry weight of organisms and is next only to water.
- Globally **71% of carbon is found dissolved in oceans**. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere (see image below). In deep oceans

such carbon can remained buried for millions of years till geological movement may lift these rocks above sea level. These rocks may be exposed to erosion, releasing their carbon dioxide, carbonates and bicarbonates into streams and rivers.

- **The atmosphere only contains about 1% of total global carbon.**
- **Fossil fuel** – it is also a reservoir of carbon.
- Carbon cycling occurs through **atmosphere, ocean and through living and dead organisms**.

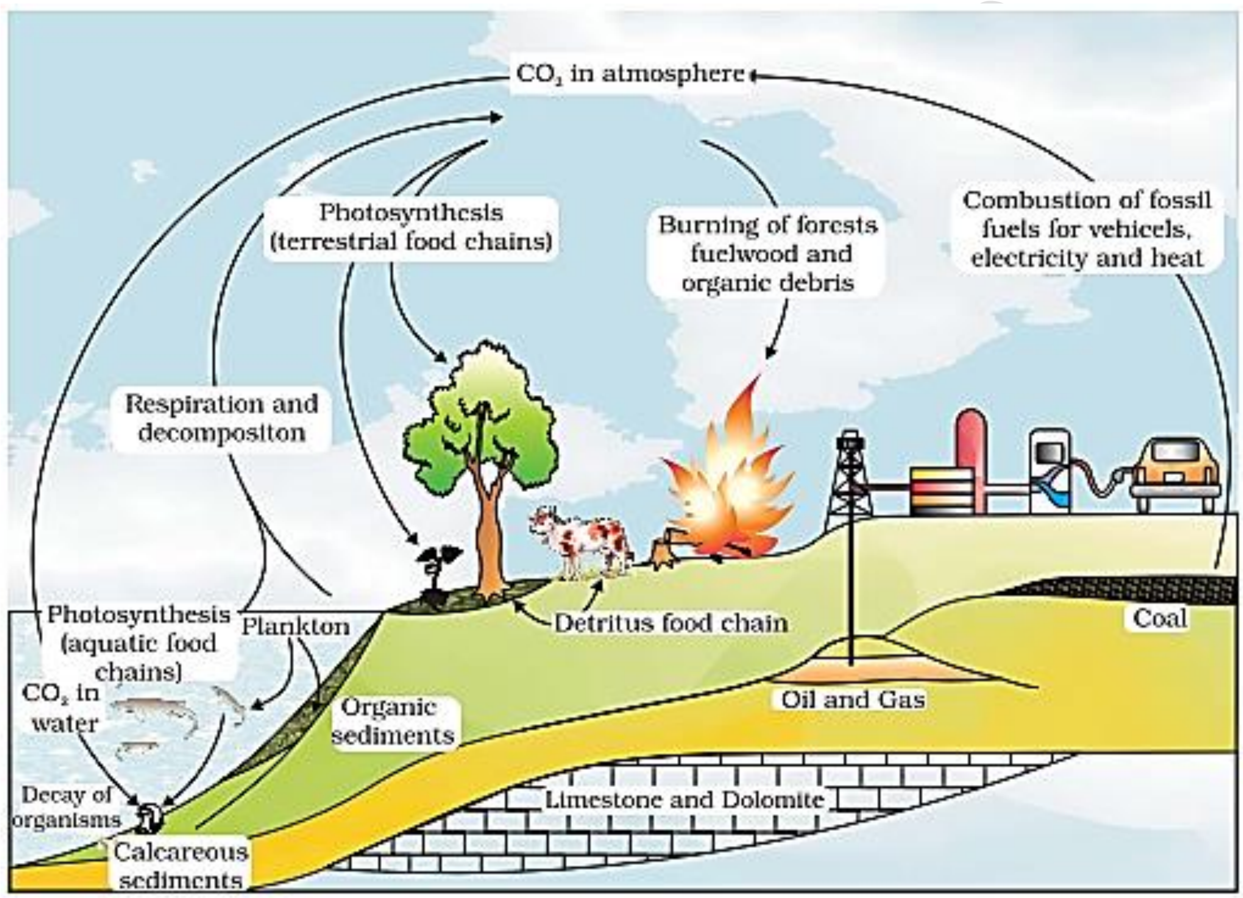


Figure 27 Simplified carbon cycle in Biosphere

- **Photosynthesis** – photosynthesis fix 4×10^{13} kg of carbon annually.
- A considerable amount of carbon returns to the atmosphere as CO2 through respiratory activities of the **producers** and **consumers**.
- **Decomposers** also contribute substantially to CO2 pool by their processing of waste materials and dead organic matter of land or oceans.
- **In form of Sediments** - Some carbon also enters a long term cycle. It accumulates as undecomposed organic matter in **the peaty layers of marshy soil or as insoluble carbonates** in bottom sediments of aquatic systems which take a long time to be released.

- **Additional sources which releases CO2 in the atmosphere** - Burning of wood, forest fire and combustion of organic matter, fossil fuel, volcanic activity.
- **Human activities** have significantly influenced the carbon cycle.
- **Rapid deforestation and massive burning of fossil fuel** for energy and **transport** have significantly increased the rate of release of carbon dioxide into the atmosphere. (more in Greenhouse effect).

THINK!

Consider the following:

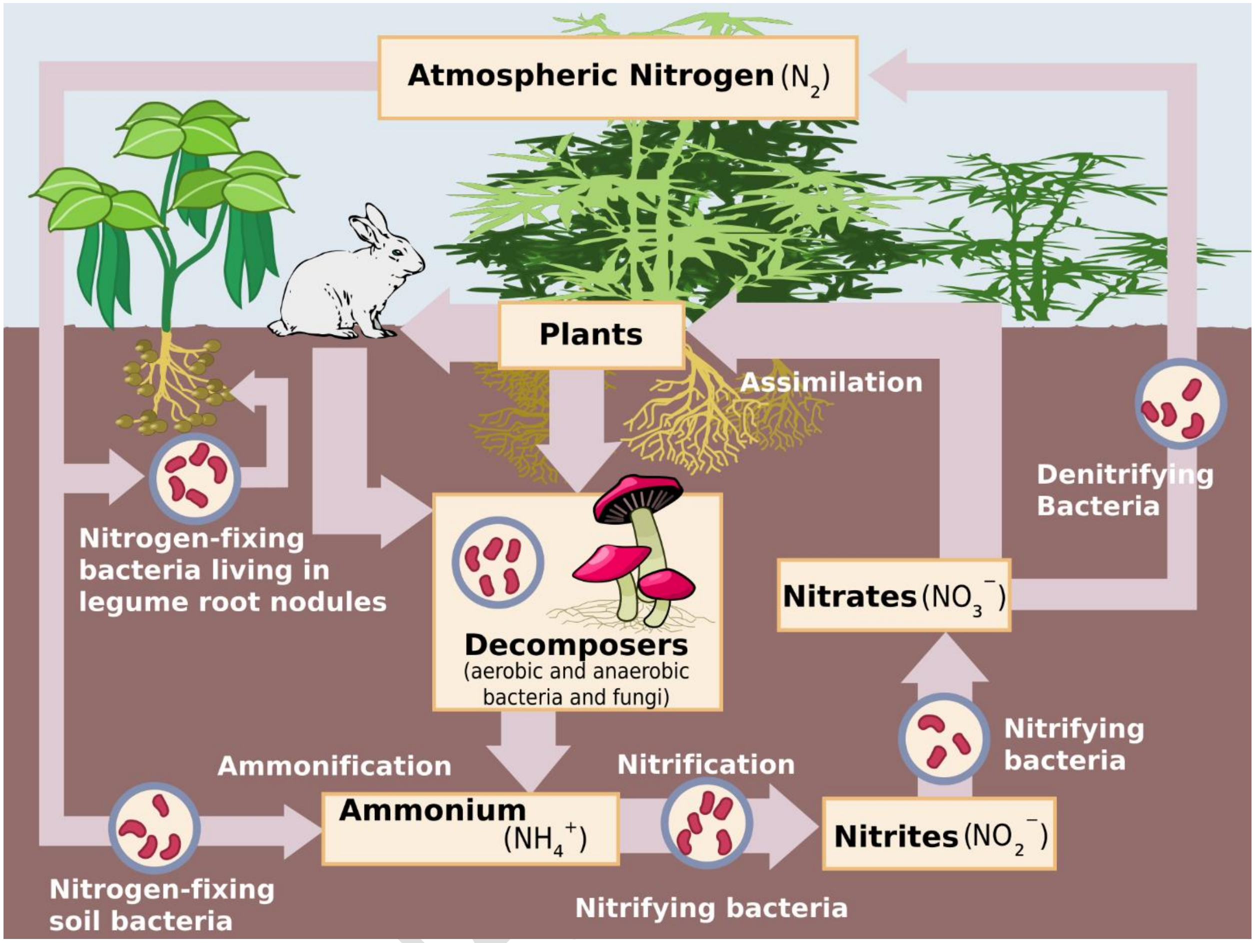
1. Photosynthesis
2. Respiration
3. Decay of organic matter
4. Volcanic action

Which of the above add carbon dioxide to the carbon cycle on Earth?

a) 1 and 4 only
b) 2 and 3 only
c) 2,3 and 4 only
d) 1, 2, 3 and 4

Solution: Find out?

Nitrogen Cycle



- Apart from carbon, hydrogen and oxygen, nitrogen is the most prevalent element in living organisms.
- Nitrogen is a constituent of **amino acids, proteins, hormones, chlorophylls** and many of the **vitamins**.
- Plants compete with microbes for the limited nitrogen that is available in soil. Thus, nitrogen is a **limiting nutrient** for both natural and agricultural ecosystems.
- Nitrogen exists as two nitrogen atoms (N2) joined by a very strong **triple covalent bond** (N ≡ N).
- In nature, **lightning** and **ultraviolet radiation** provide enough energy to convert nitrogen to nitrogen oxides (NO, NO2, N2O).
- Industrial combustions, forest fires, automobile exhausts and power generating stations are also sources of atmospheric nitrogen oxides (NO). (Diesel engine emits **NO 20 times more** than petrol engines)

Nitrogen Fixing – Nitrogen to Ammonia (N_2 to NH_3)

- There is an inexhaustible supply of nitrogen in the atmosphere but the **elemental form cannot be used directly by most of the living organisms.**
- Nitrogen needs to be '**fixed**', that is, **converted to ammonia, nitrites or nitrates**, before it can be taken up by plants.
- **Nitrogen fixation** on earth is accomplished in three different ways:
    - *By **microorganisms** (bacteria and blue-green algae),*
    - *By man using industrial processes (**fertilizer** factories) and*
    - *To a limited extent by atmospheric phenomenon such as **thunder and lighting**.*
- Certain microorganisms are capable of fixing atmospheric nitrogen into **ammonia (NH_3)** and **ammonium ions (NH_{4+})**.

  Ammonia is a molecule consisting of nitrogen and hydrogen having molecular NH_3, while ammonium (NH_{4+}) is an ion of ammonia that is formed by accepting hydrogen ion.

- The enzyme, **nitrogenase** which is capable of **nitrogen reduction** is present exclusively in **prokaryotes**. Such microbes are called **N_2-fixers**. These include:

  1. free living nitrogen fixing bacteria (non-symbiotic nitrogen fixing bacteria or nitrogen fixing soil bacteria) (e.g. *aerobic* **Azotobacter** and **Beijemickia**; *anaerobic* **Clostridium** and **Rhodospirillum**),

  2. symbiotic nitrogen fixing bacteria (e.g. **Rhizobium**) living in association with leguminous plants and non-leguminous root nodule plants and

  3. some cyanobacteria (major source of nitrogen fixation in oceans) **(blue green algae. E.g. Nostoc, Anabaena, Spirulina etc.)**.

  ***Leguminous:** denoting plants of the pea family (Leguminosae), typically having seeds in pods, distinctive flowers, and root nodules containing nitrogen-fixing bacteria.*

Nitrification – Ammonia to Nitrates

- Ammonium ions can be directly taken up as a source of nitrogen by some plants.
- Others absorb **nitrates** which are obtained by oxidizing ammonia and ammonium ions.
- Ammonia and ammonium ions are oxidized to **nitrites or nitrates** by two groups of specialized bacteria.
    - **Ammonium** ions are first oxidized to **nitrite** by the bacteria ***Nitrosomonas and/or Nitrococcus.***

- The **nitrite** is further oxidized to nitrate with the help of the bacterium ***Nitrobacter***.

- These steps are called **nitrification**. These nitrifying bacteria are **chemoautotrophs**.
- The nitrate thus formed is absorbed by plants and is transported to the leaves.
- In leaves, it is reduced to form ammonia that finally forms the amine group of **amino acids**, which are the building blocks of proteins. These then go through higher trophic levels of the ecosystem.

Nitrification is important in agricultural systems, where fertilizer is often applied as ammonia. Conversion of this ammonia to nitrate increases nitrogen leaching because nitrate is more water-soluble than ammonia.

*Nitrification also plays an important role in the removal of nitrogen from municipal wastewater. The conventional removal is **nitrification**, followed by **denitrification**.*

Ammonification – Urea, Uric Acid to Ammonia

- Living organisms produce nitrogenous waste products such as urea and uric acid (organic nitrogen).
- These waste products as well as dead remains of organisms are converted back into inorganic ammonia and ammonium ions by the bacteria. This process is called ammonification.
- Some of this ammonia volatilizes and re-enters the atmosphere but most of it is converted into **nitrate** by soil bacteria.

Denitrification – Nitrate to Nitrogen

- Nitrate present in the soil is **reduced to nitrogen** by the process of **denitrification**.
- In the soil as well as oceans there are special denitrifying bacteria (**Pseudomonas** and **Thiobacillus**), which convert the nitrates/nitrites to elemental nitrogen. This nitrogen escapes into the atmosphere, thus completing the cycle.

Step 1: N2 Fixing → Nitrogen → Ammonia or Ammonium Ions
Step 2: Nitrification →Ammonia or Ammonium Ions → Nitrite → Nitrate
Step 3: Ammonification→ Dead Matter + Animal Waste (Urea, Uric Acid) → Ammonia or Ammonium Ions.

Dead Matter + Animal Waste (Urea, Uric Acid) → Ammonia or Ammonium Ions [most of it escapes into atmosphere. Rest is Nitrified **(Step 2) to** nitrates]

Nitrate [some of it is available for plants. Rest is Denitrified **(Step 4)**]

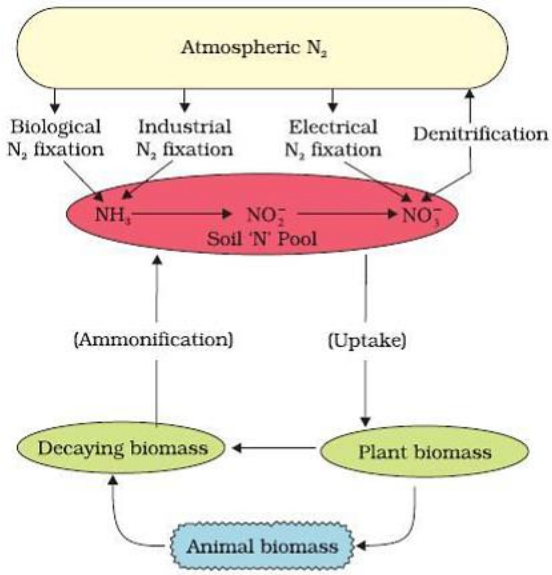


Figure 12.3 The nitrogen cycle showing relationship between the three main nitrogen pools – atmospheric soil, and biomass

Step 4: Denitrification ➔ Nitrate → Nitrogen.

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

THINK

Which of the following adds/add nitrogen to the soil?

1. Excretion of urea by animals
2. Burning of coal by man
3. Death of vegetation

Select the correct answer using the codes given below.

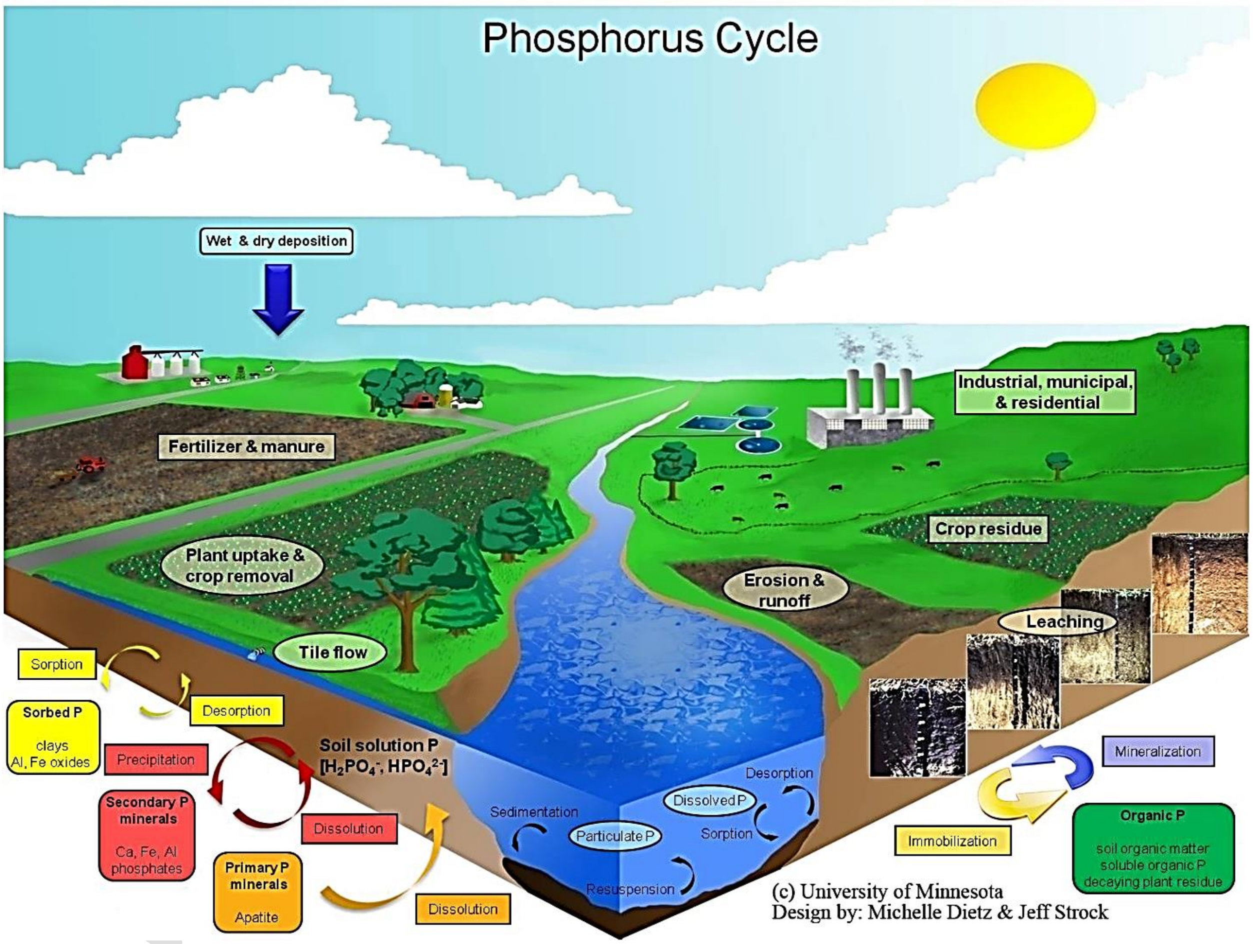
a) 1 only
b) 2 and 3 only
c) 1 and 3 only
d) 1, 2 and 3

Solution: Find out?

Sedimentary Cycle

1. The sedimentary cycle's (e.g., sulphur and phosphorus cycle) reservoir is located in Earth's crust.
2. It follows a basic pattern of flow through erosion, sedimentation, mountain building, volcanic activity and biological transport through the excreta of marine birds.

Phosphorous Cycle



High resolution – [click here]

- Phosphorus plays a central role in aquatic ecosystems and water quality.
- Unlike carbon and nitrogen, which come primarily from the atmosphere, phosphorus occurs in large amounts as a mineral in phosphate rocks and enters the cycle from **erosion and mining activities**.

- This is the nutrient considered to be the main cause of excessive growth of rooted and free-floating microscopic plants (phytoplankton) in lakes [**Eutrophication**].
- The main storage for phosphorus is in the earth's crust. On land phosphorus is usually found in the form of **phosphates**.
- By the process of **weathering and erosion** phosphates enter rivers and streams that transport them to the ocean.
- In the ocean phosphorus accumulates on continental shelves in the form of **insoluble deposits.**
- After millions of years, the crustal plates rise from the sea floor and expose the phosphates on land.
- After more time, weathering will release them from rock and the cycle's geochemical phase begins again.

Sulphur Cycle

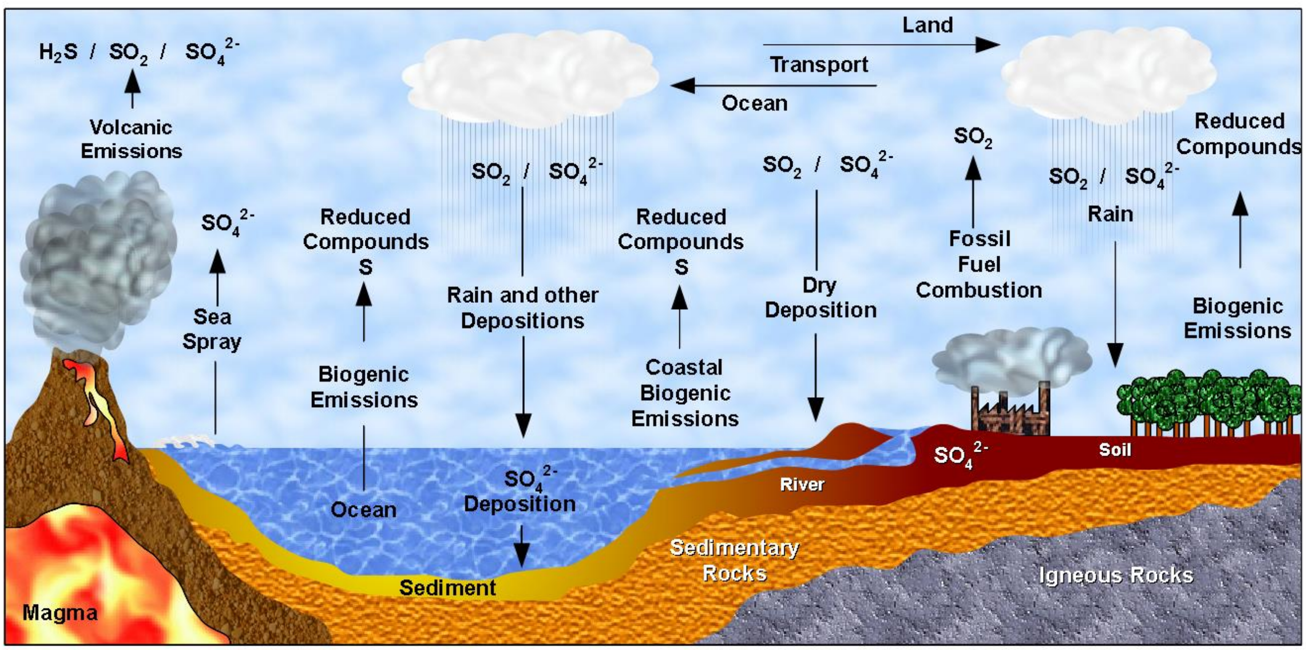


Figure 28 Sulphur cycle

- The sulphur reservoir is in the soil and sediments where it is locked in organic (**coal, oil and peat**) and inorganic deposits (**pyrite rock and sulphur rock**) in the form of **sulphates, sulphides** and **organic sulphur**.
- It is released by weathering of rocks, erosional runoff and decomposition of organic matter and is carried to terrestrial and aquatic ecosystems in salt solution.

- The sulphur cycle is mostly sedimentary except two of its compounds – **hydrogen sulphide (H2S)** and **sulphur dioxide (SO2)** which add a **gaseous component**.
- Sulphur enters the atmosphere from several sources like **volcanic eruptions, combustion of fossil fuels (coal, diesel etc.)**, from **surface of ocean** and from **gases released by decomposition**. Atmospheric hydrogen sulphide also gets oxidized into sulphur dioxide.
- Atmospheric sulphur dioxide is carried back to the earth after being dissolved in rainwater as weak **sulphuric acid**.
- Whatever the source, sulphur in the form of **sulphates** is take up by plants and incorporated through a series of metabolic processes into **sulphur bearing amino acid** which is incorporated in the proteins of autotroph tissues. It then passes through the grazing food chain.
- Sulphur bound in living organism is carried back to the soil, to the bottom of ponds and lakes and seas through **excretion and decomposition** of dead organic material.

Succession

- Biotic communities are dynamic in nature and change over a period of time. The process by which communities of plant and animal species in an area are replaced or changed into another over a period of time is known as ecological succession.
- It is the process of change in the species structure of an ecological community over time. The time scale can be decades (for example, after a wildfire), or even millions of years after a mass extinction.
- The community begins with relatively few pioneering plants and animals and develops through increasing complexity until it becomes stable or self-perpetuating as a climax community.
- The "engine" of succession, the cause of ecosystem change, is the impact of established species upon their own environments.

Pioneer community

- The first plant to colonize an area is called the pioneer community.

Climax community

- The final stage of succession is called the climax community.

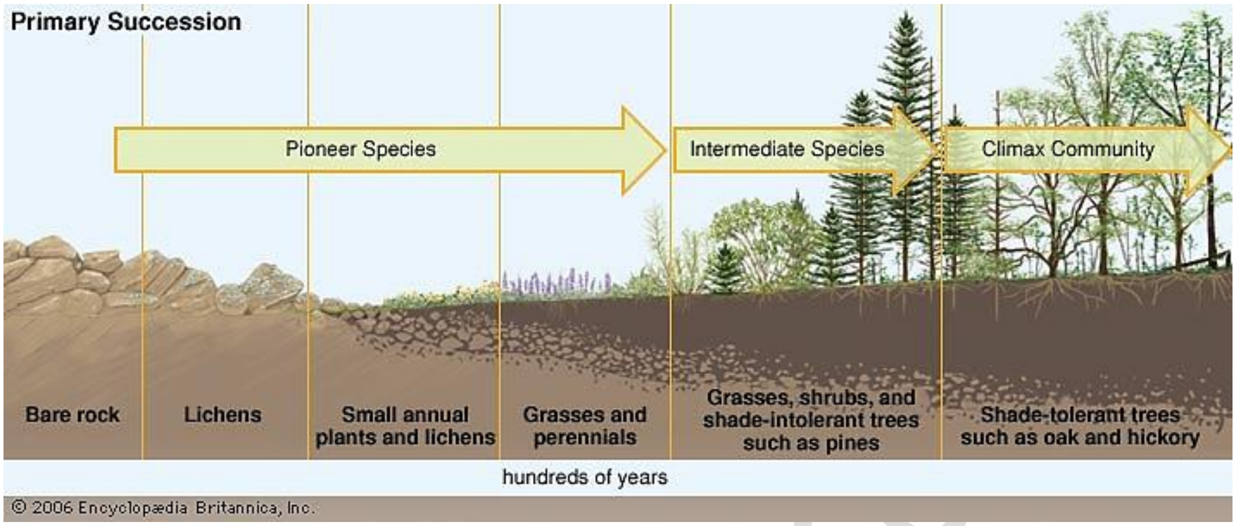
Successional stages or sere

- The stage leading to the climax community is called successional stages or **seres.**
- Succession is characterized by the following - increased productivity, the shift of nutrients from the reservoirs, increased diversity of organisms with increased niche development, and a gradual increase in the complexity of food webs.
- Succession would occur faster in area existing in **the middle of the large continent**. This is because, here seeds of plants belonging to the different seres would reach much faster, establish and ultimately result in climax community.
- Succession that occurs on land where moisture content is low for e.g. on bare rock is known as **xerarch**. Succession that takes place in a water body, like ponds or lake is called **hydrarch**.

Succession explanation video – click here

Primary succession

- Primary succession takes place an over a **bare or unoccupied areas** such as rocks outcrop, newly formed *deltas and sand dunes, emerging volcano islands and lava flows as well as glacial moraines* (muddy area exposed by a retreating glacier) where no community has existed previously.
- The first inhabitants are lichens or plants—those that can survive in such an environment.
- Over hundreds of years these "**pioneer species**" convert the rock into soil by secreting acids to dissolve rock, helping in weathering and soil formation that can support simple plants like bryophytes, which are able to take hold in the small amount of soil.
- These plants further modify the soil, which is then colonized by other types of plants.
- Each successive stage modifies the habitat by altering the amount of shade and the composition of the soil.
- The final stage of succession is a **climax community**, which is a very stable stage that can endure for hundreds of years.
- In primary succession in water, the **pioneers** are the small phytoplanktons, they are replaced with time by free-floating angiosperms, then by rooted hydrophytes, sedges, grasses and finally the trees.
    - The climax again would be a forest. With time the water body is converted into land.


Primary Succession
Pioneer Species
Intermediate Species
Climax Community
Bare rock
Lichens
Small annual plants and lichens
Grasses and perennials
Grasses, shrubs, and shade-intolerant trees such as pines
Shade-tolerant trees such as oak and hickory
hundreds of years
© 2006 Encyclopædia Britannica, Inc.

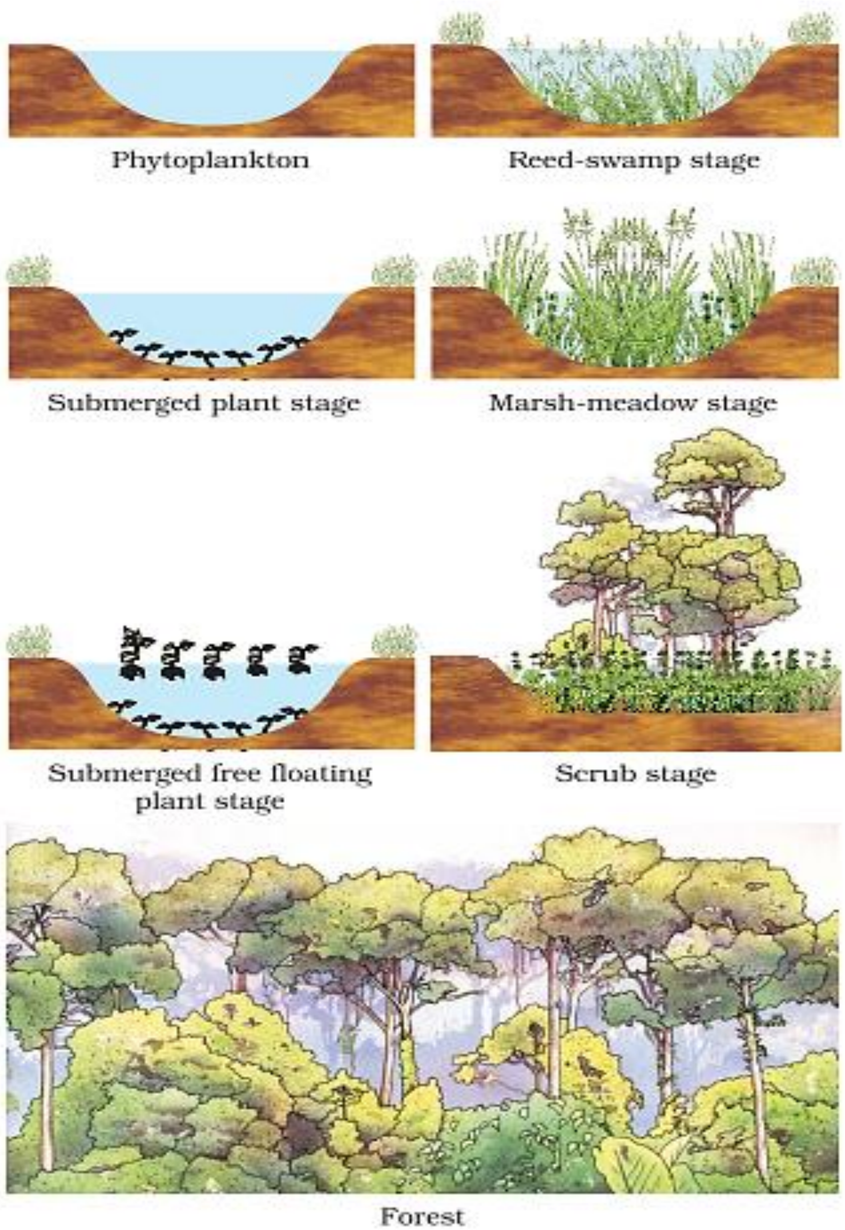
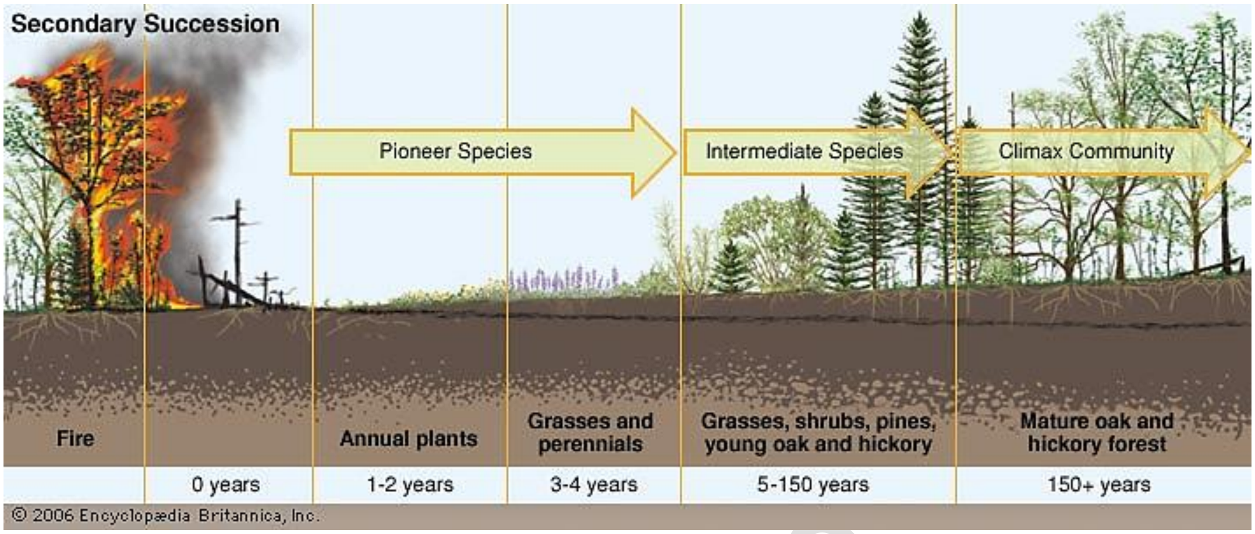


Figure 29 Diagrammatic representation of primary succession

Secondary Succession



- Secondary succession follows a **major disturbance**, such as a fire or a flood.
- The **stages of secondary succession are similar to those of primary succession**; however, primary succession always begins on a barren surface, whereas secondary succession begins in environments that already possess soil.
- In addition, through a process called **old-field succession**, farmland that has been abandoned may undergo secondary succession.

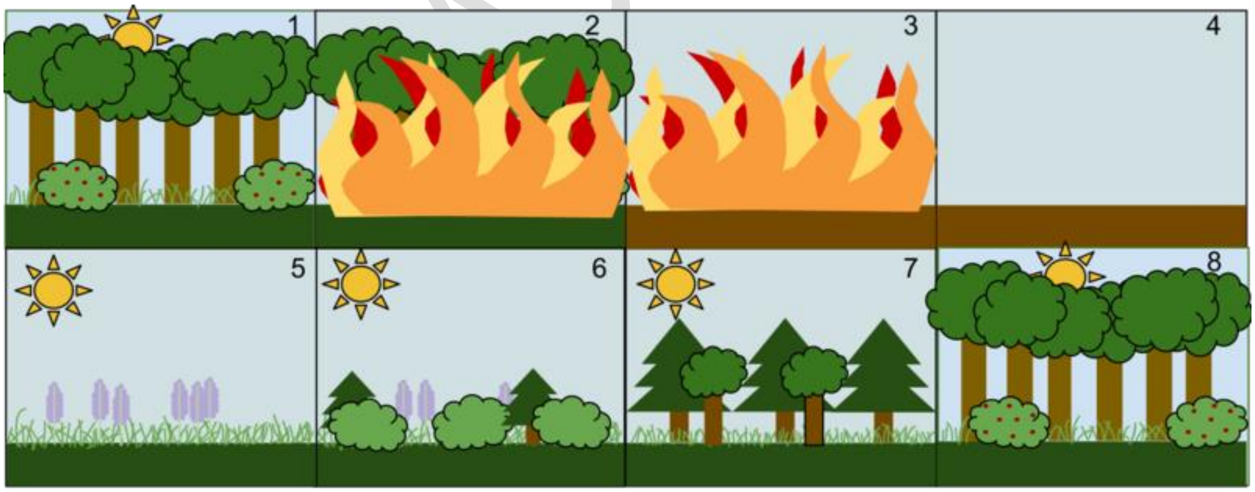


Figure 30 Secondary succession and also See the steps below

An example of Secondary Succession by stages:

- A stable deciduous forest community
- A disturbance, such as a wild fire, destroys the forest
- The fire burns the forest to the ground
- The fire leaves behind empty, but not destroyed, soil
- Grasses and other herbaceous plants grow back first
- Small bushes and trees begin to colonize the area
- Fast growing evergreen trees develop to their fullest, while shade-tolerant trees develop in the understory
- The short-lived and shade intolerant evergreen trees die as the larger deciduous trees overtop them. The ecosystem is now back to a similar state to where it began.

Autogenic succession

- When succession is brought about by living inhabitants of that community itself, the process is called autogenic succession.
- It is driven by the biotic components of an ecosystem.

Allogenic succession

- Change brought about by outside forces is known as allogenic succession.
- Allogenic succession is driven by the abiotic components of the ecosystem.

Auto·trophic and Heterotrophic succession

- Succession in which, initially the green plants are much greater is quantity is known as **autotrophic succession.**
- Succession in which the heterotrophs are greater in quantity is known as heterotrophic succession.
- Succession would occur faster in area existing in the middle of the large continent. This is because here all propagules or seeds of plants belonging to the different seres would reach much faster, establish and ultimately result in climax community.