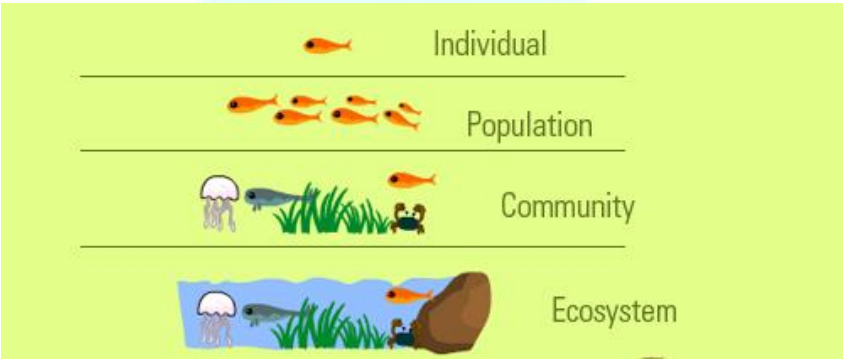
ECOLOGY

Ecology is the study of the relationships among organisms and the relationship between them and their surroundings.

The term "**ecology**" was coined by combining two Greek words, **oikos** (house or dwelling place), and **Logos** (the study of), to denote the relationship between organisms and their environment.

BASIC CONCEPT OF ECOLOGY:

i. All living organisms and the environment they live in are mutually reactive, affecting each other in various ways.
ii. Environment plays a major role in the critical stages of the life cycle of the species.
iii. The species reacts to the environmental changes and adjusts itself structurally and physiologically.
iv. The environment also changes according to certain species- specific activities like growth, dispersal, reproduction, death, decay, etc.
v. All plants and animals are related to each other by their coaction and reaction on the environment.
vi. Under similar climatic conditions, there may simultaneously develop more than one community, some reaching the climax stage, and others under different stages of succession.



- A group of individual organisms of the same species in a given area is called a Population.
- While, a group of populations of different species in a given area is called a Community.

POPULATION	COMMUNITY
A group of interbreeding individuals of the same species, which is isolated from the other group	A group or the association of populations of two or more different species occupying the same geographical area at a particular time
A small group in an ecosystem	Comparatively large group
Consist of single species	Consist of several species living together
All the individuals are morphologically and behaviourally similar	Individuals can be categorised into groups in terms of morphology and behaviour
Individuals interbreed freely	Interbreeding is absent
Intra-specific competition occurs among the individuals	Inter-specific competition occurs among the individuals
No pray-predator relationship among individuals	Pre- predator relationship present among individuals

- And, an ecosystem or an ecological system is the whole biotic community in a given area and its abiotic environment.
- It therefore includes the physical and chemical nature of the sediments, water and gases as well as all the organisms.
- An ecosystem can be any size, from an area as small as a pinhead to the whole biosphere.
- The term was first used in the 1930s to describe the interdependence of organisms among themselves and with the living (biotic) and non-living (abiotic) environment.
- The overall view of this type of approach is that living organisms and their non-living environment are inseparably interrelated and interact with each other.
- A.G. Tansley in 1935 proposed the term "ecosystem".
- Eco implies the environment, and 'system' 'implies an interacting, interdependent complex.
- Ecosystem Ecology emphasises the movements of energy and nutrients (chemical elements) among the biotic and abiotic components of ecosystems.

CONCEPTS OF AN ECOSYSTEM :

Following are the basic concepts of an ecosystem:

i. When both biotic and abiotic components are considered, the basic structural and functional units of nature are ecosystems.
ii. There exist varying degrees of positive, negative and even neutral interactions among organisms at both inter- and intra-specific levels.
iii. Energy is the driving force of an ecosystem which is unidirectional or non-cyclic.
iv. The chemical components of the ecosystem move in a defined path called biogeochemical cycles.
v. Successful growth of the organism is governed by limiting factors.
vi. The minimal and maximum levels of tolerance for all species vary seasonally, geographically and according to the population.
vii. Under natural conditions, different kinds of population undergo succession.

KINDS OF ECOSYSTEM:

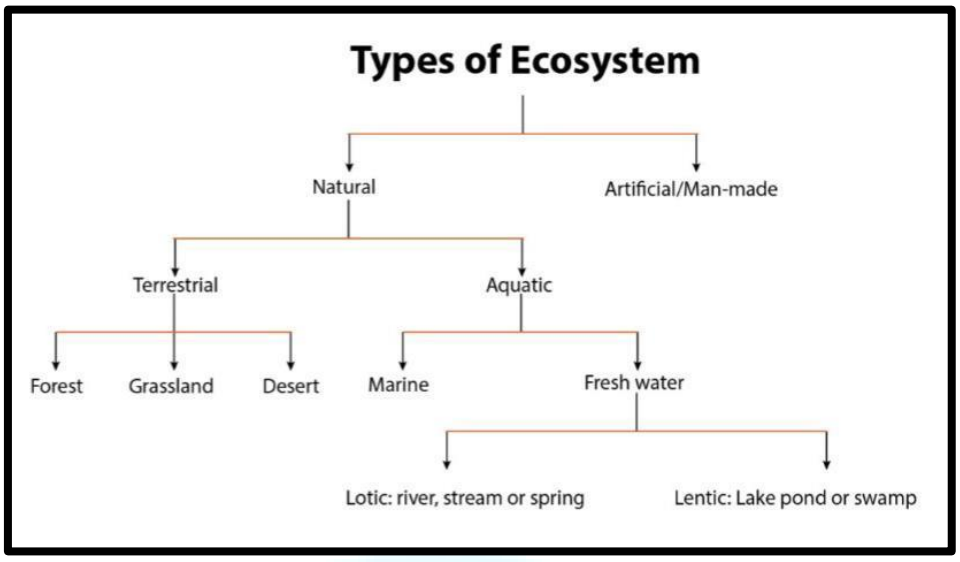
1. **NATURAL ECOSYSTEMS**
2. **ARTIFICIAL ECOSYSTEMS**

1. NATURAL ECOSYSTEMS:

- These operate under natural conditions without any major interference by man. These are further divided into;
    a. Terrestrial
       Eg: Forest, grassland, desert, etc.
    b. Aquatic
       Eg: Ocean, Pond, river etc.
       These may be further classified into two;
       (a) freshwater and
       (b) marine

2. ARTIFICIAL ECOSYSTEMS:

- These are maintained artificially by humans where, by addition of energy and planned manipulations, natural balance is disturbed regularly.
- Eg: croplands like wheat, rice fields, etc., where humans try to control the biotic community as well as the physio- chemical environments, are artificial ecosystems.



STRUCTURE OF AN ECOSYSTEM

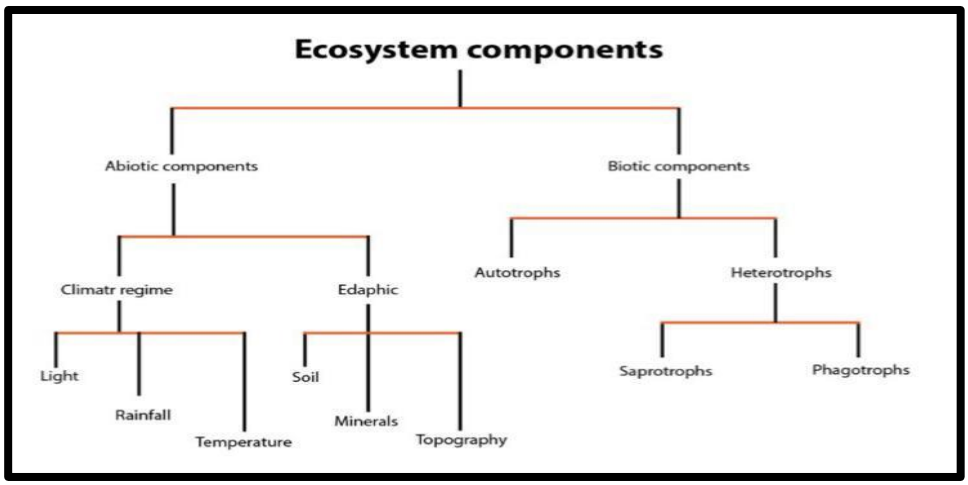
- An ecosystem has two major components:
    1. **Abiotic (non-living) component**
    2. **Biotic (living) component**

1. **Abiotic (non-living) component**:

- It includes inorganic substances, inorganic chemicals and climate of the given region.

2. **Biotic (living) component**:

- It can be further classified as:
    A. Autotrophic component
    B. Heterotrophic component
- It further divided into
    a. Macroconsumers: herbivores, carnivores, omnivores.
    b. Microconsumers: bacteria, actinomycetes and fungi.



FUNCTIONAL ASPECTS OF AN ECOSYSTEM:

i. The rate of biological energy flow, i.e., the production and respiration rates of the community.
ii. The rate of materials or nutrient cycles.
iii. Biological or ecological regulation including both regulation of organisms by environment and regulation of environment by the organism.

HABITAT

- This is a specific place or locality where an organism lives.
- It is a physical entity that comprises of the sum total of the abiotic factors to which a species or a group of species is exposed.
- Habitat usually refers to a relatively large area, such as a pond, a forest, an estuary or an ocean.
- Habitats are characterized by conspicuous physical features, which include the dominant forms of plant and animal life.
- The habitat may be referred to the place occupied by an entire biological community.
- For example, a large number of species of plants and animals are formed in a forest habitat.

- The habitats can be further subdivided into parts, which exhibit distinct properties and give shelter to different types of organisms, such habitats are called microhabitats.
- For example, the muddy bottom and a surface water of a pond tree canopy and forest floor are microhabitats.
- Some animals are very specific to their habitat, while others have wider choices.
- For example, Fubifex, an annelid lives in flowing fresh water which is rich both in organic content and oxygen on the other hand, the Chironomous larvae (insect larvae) can survive in water with very low oxygen content.
- Certain fishes can live only in fresh water, while others e.g. Hilsa can live in both fresh water and saline water.

TYPES OF HABITAT

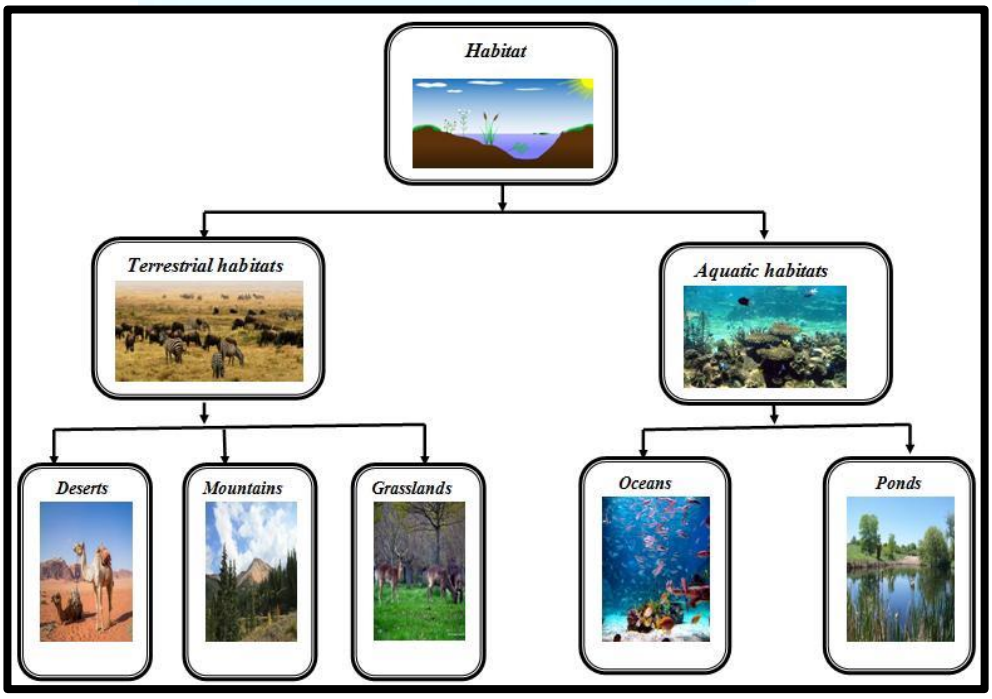
1. Terrestrial Habitats : Habitats on land are called terrestrial habitats. Terrestrial habitats are followed by:

a. Grassland : Grassland habitats are dominated by grass, small trees and shrubs. They get moderate rain, usually windy and dry.
b. Mountains : Mountains are habitats found at higher altitudes where the climate is extremely cold and windy.
c. Forests : Forest habitats are divided into three sub-division. They are Tropical forests, Temperate forests and Boreal forests. They are dominated by the presence of a large number of plants and trees.
d. Deserts : Deserts are sandy lands that receive very little rainfall, and the regions are hot and dry.
e. Polar regions : Polar regions are totally covered with snow and can experience very cold temperatures.

2. Aquatic Habitat : Habitat in water is called aquatic habitat. It is further classified into two habitats:

a. Freshwater Habitat : Freshwater habitat includes rivers, streams, ponds and lakes.

b. Marine Habitat : The saltwater habitat is called marine habitat. Planktons, seaweeds, fish, whales, crabs, octopuses, turtles, starfish, etc., are present in this habitat.



ECOLOGICAL NICHE:

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- The ecological niche of an organism represents the range of conditions that if can tolerate, the resources it utilises, and its functional role in ecological system.
- Each species of a community lives in a very specific part of a habitat and performs certain functions.
- The habitat together with the functions forms the niche of the species.
- In other words, the concept of ecological niche includes factors, such as food relations, predators, tolerance levels and other habits as well as abiotic factors.
- Each species within a community has a separate ecological niche.
- No two species within a given community can have exactly the same niche and live permanently together.
- In such case, there would be a direct competition with each other till one eliminates the other.

TYPES OF NICHES

There are 4types of Niches;

	Niche Type	Character
i.	Habitat/Spatial Niche	It illustrates microhabitat occupied by various species in a general habitat.
ii.	Trophic Niche	It is accountable for the useful role of a specific species and how the species' position is in comparison to others.
iii.	Multidimensional Niche	It benefits understanding the position of a particular species in the tip and rise of the environment.
iv.	Fundamental Niche	This niche of a species is the hyper volume that a population can fill in the absence of competitors. So each species has a fundamental niche within a community.
v.	Realized Niche	Because of competition, due to similar essentials along the niche dimension, the competitor niches will be overlying one another. As a result of these biotic constraints, only a part of the niche is realized by the species. These smaller hyper volumes occupied by a species are termed the realized niche.

- Hutchinson recognized two types of niches; fundamental niche and realized niche.

THE RELATIONSHIP BETWEEN HABITAT AND NICHE

- It is necessary to note that habitats can exist without niches.
- Habitat is the sum of all conditions for an animal to live in (potential habitat).
- A habitat is only engaged (realized habitat) when an ecosystem grows, and niches are integrated into it. This is called **habitat differentiation** and is deeply interconnected with the presence of a thriving ecosystem.
- It is possible that two animals can have the same niche (same role) in an ecosystem, provided they live in various habitats.
- For example, deer and rabbits both play the role of herbivores (an animal that feeds only on plants), but you find deer in the woody areas of a forest while rabbits are found in the open areas.

FOOD CHAIN AND FOOD WEB

- Food chain is a linear sequence of organisms which starts from producer organisms and ends with decomposer species.
- Food web is a connection of multiple food chains.
- Food chain follows a single path whereas food web follows multiple paths.
- From the food chain , we get to know how organisms are connected with each other.
- Food chain and food web form an integral part of this ecosystem.

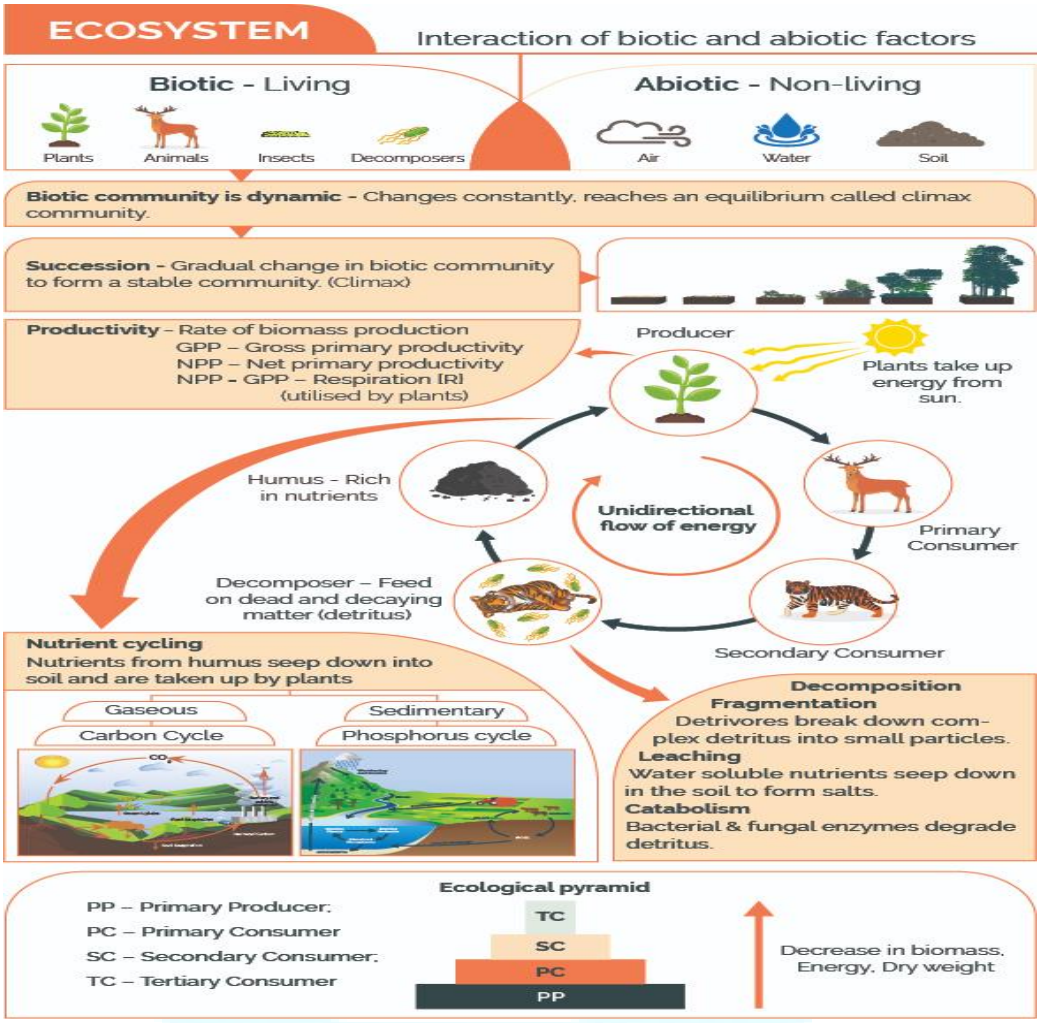
FOOD CHAINS

- In scientific terms, a food chain is a chronological pathway or an order that shows the flow of energy from one organism to the other.
- In a community which has producers , consumers , and decomposers , the energy flows in a specific pathway.
- Energy is not created or destroyed . But it flows from one level to the other , through different organisms.

- A food chain shows a single pathway from the producers to the consumers.
- The sun is the source of energy, which is the initial energy source.
- This is used by the producers or plants to create their own food , through photosynthesis and grow.
- Next in this chain is another organism , which is the consumer that eats this food , taking up that energy.
- The primary consumers are the organisms that consume the primary producers.
- In a terrestrial ecosystem , it could be a herbivore like a cow or a goat or it could even be a man. When a goat is consumed by man , he becomes the secondary consumer.
- As the energy goes one level up , the food chain also moves up . Each level in the food chain is called a trophic level . The different trophic levels are Primary producers , primary consumers , secondary consumers , tertiary consumers and quaternary consumers.
- **Example of food chain**

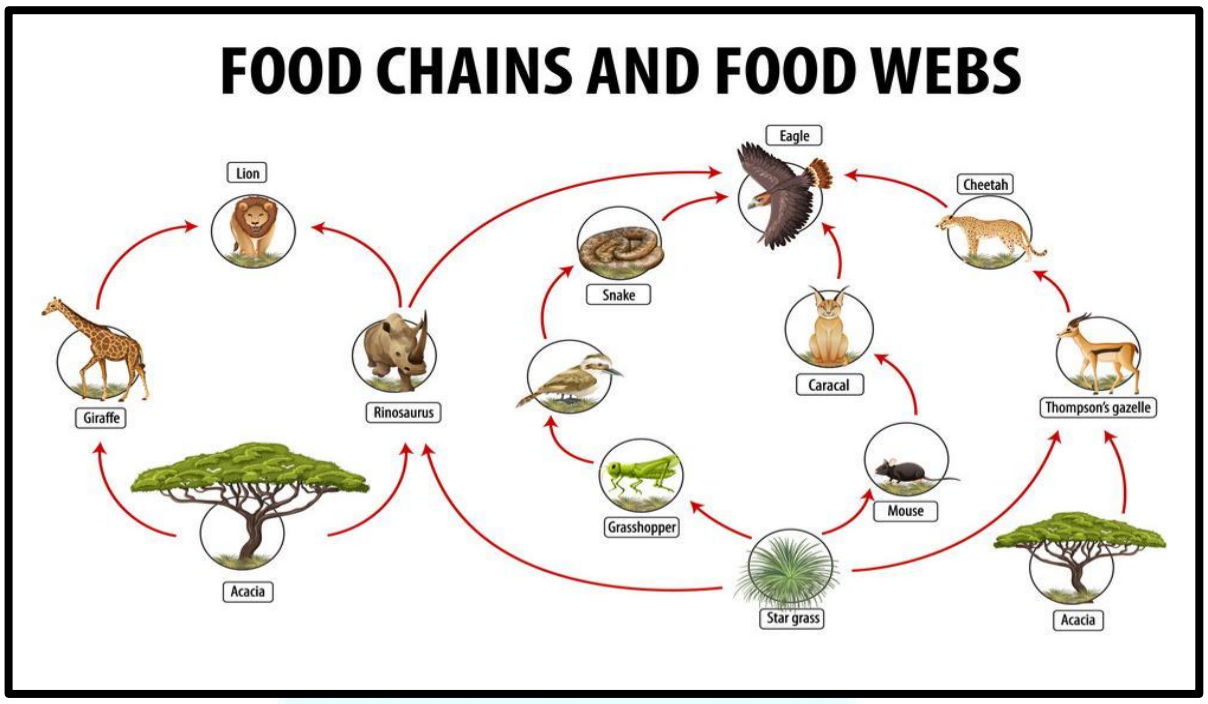
  Grass (Producer) —— Goat (Primary Consumer) —— Man (Secondary consumer)

- When dead organic matter becomes the starting of a food chain, then it is called the detritus food chain (DFC) . The decomposers , which are the fungi and bacteria , feed on the organic matter to meet the energy requirements.
- The digestive enzymes secreted by the decomposers help in the breakdown of the organic matter into inorganic materials.



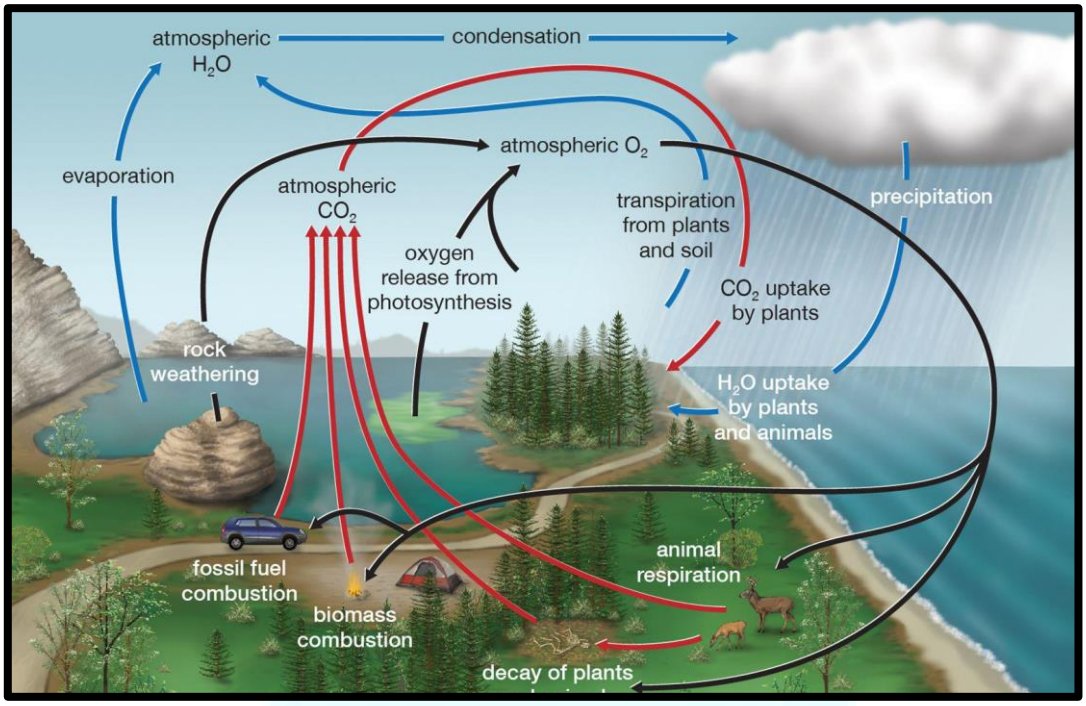
FOOD WEB

- Many interconnected food chains make up a food web . When you look at the larger picture , a food web shows a realistic representation of the energy flow through different organisms in an ecosystem.
- Sometimes, a single organism gets eaten by many predators or it eats many other organisms.
- This is when a food chain doesn't represent the energy flow in a proper manner because there are many trophic levels that interconnect. This is where a food web comes into place. It shows the interactions between different organisms in an ecosystem .



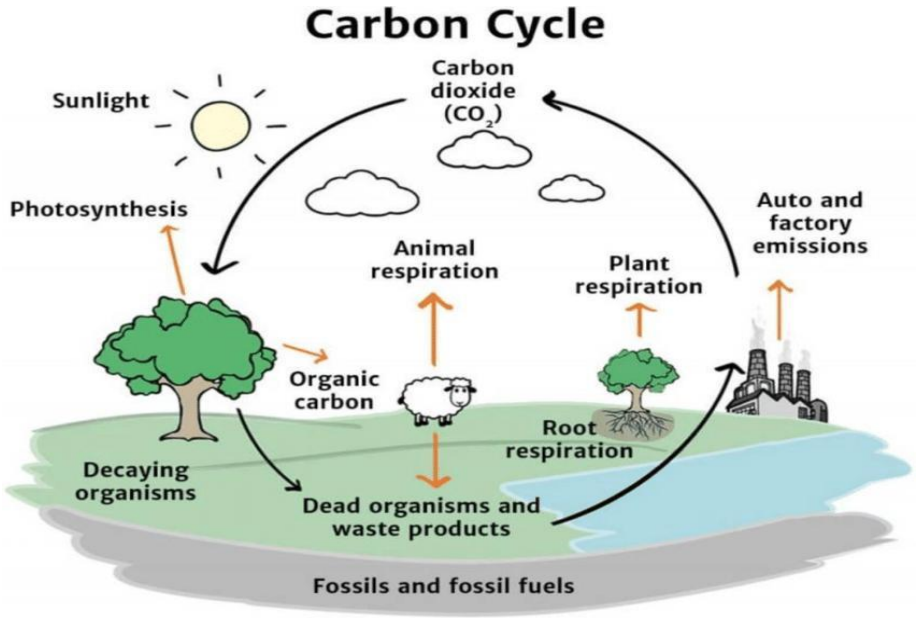
BIOGEOCHEMICAL CYCLES

- In the first place , Energy flows directionally through ecosystems , entering as sunlight and leaving as heat during the many transfers between trophic levels.
- The biogeochemical is a contraction that refers to the consideration of the biological , geological , and chemical aspects of each cycle.
- Further , biogeochemical cycles flow in different forms from the nonliving components of the biosphere to the living components and back.
- Each biogeochemical cycle can be defined as having a reservoir pool , a larger and an exchange pool concerned with the rapid exchange between the biotic and abiotic aspects of an ecosystem.
- Gaseous Cycles – includes the Nitrogen , Carbon , Oxygen and Water Cycle.
- Further , Gaseous cycles tend to move more rapidly to adjust to changes in the biosphere because of the large atmospheric reservoir.
- They are perfect nutrients.
- Sedimentary Cycles – includes the Rock , Phosphorus and Sulphur cycle.
- This cycle vary from one element to another , but each cycle consists fundamentally of a solution.
- These are imperfect as some nutrients lost get locked into sediments and are unavailable for immediate cycling .



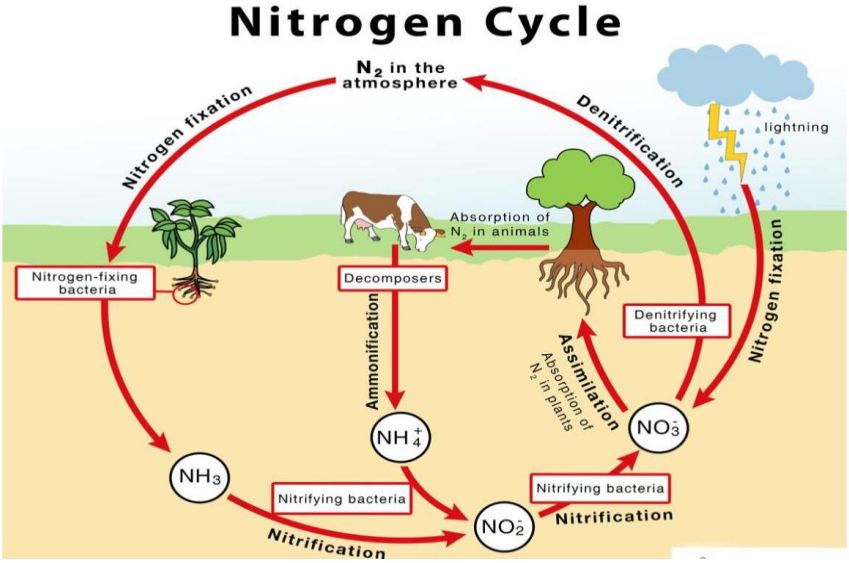
CARBON CYCLE

- Carbon s one of the most vital elements for the happening of all cycles on earth . It is present in the atmosphere as carbon dioxide.
- Besides , you can see it as the most expensive substance diamond. It's located in proteins , carbohydrates , fats , nucleic acids , vitamins , and minerals.
- As we all know , all green plants use carbon dioxide and sunlight for photosynthesis. Carbon is thus present in the plant. Further , the green plants , when dead , are buried into the soil that gets converted into fossil fuels made from carbon.
- Also , carbon is mainly produced when present in the form of fossil fuels (coal & oil) . Further , it can be extracted for various commercial and non - commercial purposes.



NITROGEN CYCLE

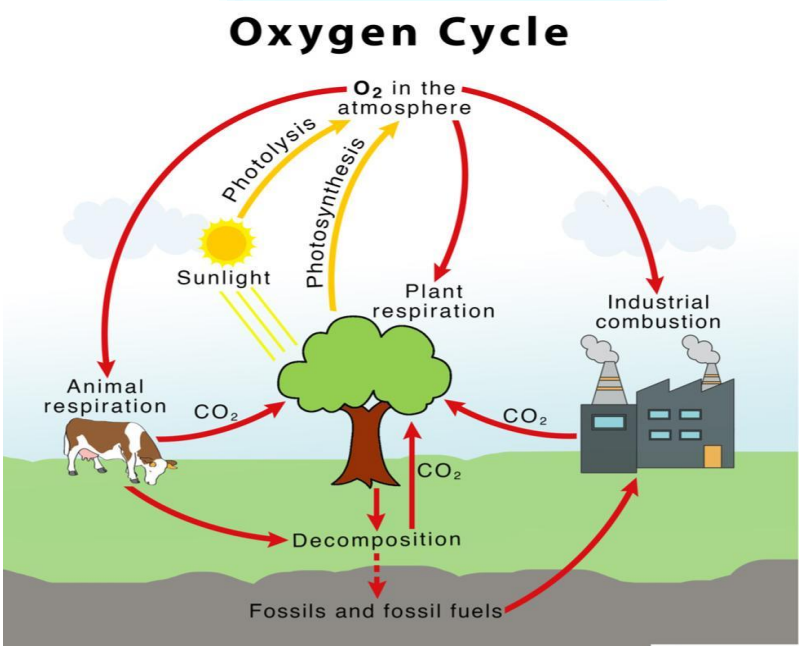
- it is a biogeochemical cycle by which nitrogen is converted into several forms , and it gets circulated through the atmosphere and various ecosystems such as terrestrial and marine ecosystems.
- Besides , our atmosphere includes around 78 % of nitrogen , and nitrogen is present in proteins and essential nucleic acids like DNA and RNA.
- Further , you can find it in alkaloids and urea. Then , the nitrogen - fixing bacteria is located in the roots of legumes in part called root nodules.
- Additionally , the bacteria present in the origins of the plants convert this nitrogen gas into a usable compound called ammonia , and ammonia is supplied to plants in the form of fertilizers.



- Amino acids are essential to make proteins. Further , animals consume proteins (animals eat plants that contain proteins). Besides , these animals die , bacteria in the soil convert nitrogen compounds back into nitrates and nitrites . Nitrogen passes from elemental in the atmosphere into nitrates and nitrites in soil and water.

OXYGEN CYCLE

- oxygen is one of the essential elements. 21% of the earth's atmosphere consists of oxygen.
- Besides , you will find oxides of metals , silicon , carbonate , sulfate , nitrate , and other minerals in the earth's crust . Humans and other animals inhale the oxygen exhale carbon dioxide , which the plants again take up.



TYPES OF BIOGEOCHEMICAL CYCLES

1) Water Cycle:

- water evaporates from the water bodies , and the condensation of this water vapor leads to rain.
- Then , the biogeochemical cycle is responsible for maintaining weather conditions . The process in which water evaporates and falls on the land as rain and later gets back to see through rivers is called a Water - cycle.

- Besides , a small amount of water goes down into the soil and becomes part of the underground water . Water flows through or over rocks that contain soluble minerals.

2) Phosphorus Cycle:

- Concerning the Phosphorus Cycle , phosphorus moves through the hydrosphere , lithosphere , and biosphere . Besides , it is extracted by the weathering of rocks . Due to rains and erosion , phosphorus is washed away in the soil and water bodies.

3) Sulphur Cycle

- The biogeochemical cycle moves through the rocks , water bodies , and living systems . Then , the sulfur is released into the atmosphere by rocks' weathering and converted into sulfates.
- Further , these sulfates are taken up by the microorganisms and plants and converted into organic forms . Finally , animals consume it through food and when these animals are decomposed.

IMPORTANCE OF BIOGEOCHEMICAL CYCLES

- In the first place , all these cycles through the ecosystem and move all vital elements for life to sustain.
- Further , these are important elements through the physical facets.
- These all cycles depict the association between living and nonliving things in the ecosystems and enable the continuous survival of ecosystems.
- Besides, it is essential to comprehend these cycles to learn their effect on living entities.
- Later , some activities of humans disturb a few of these natural cycles and thereby affecting related ecosystems.

ENVIRONMENTAL POLLUTION

- Developmental activities such as construction, transportation and manufacturing not only deplete the natural resources but also produce large amount of wastes that leads to pollution of air, water, soil, and oceans; global warming and acid rains.
- Untreated or improperly treated waste is a major cause of pollution of rivers and environmental degradation causing ill health and loss of crop productivity.

POLLUTION AND POLLUTANTS

- Human activities directly or indirectly affect the environment adversely.
- A stone crusher adds a lot of suspended particulate matter and noise into the atmosphere.
- Automobiles emit from their tail pipes oxides of nitrogen, sulphur dioxide, carbon dioxide, carbon monoxide and a complex mixture of unburnt hydrocarbons and black soot which pollute the atmosphere.
- Domestic sewage and run off from agricultural fields, laden with pesticides.
- Contemporary Environmental Issues and fertilizers, pollute water bodies. Effluents from tanneries contain many harmful chemicals and emit foul smell. These are only a few examples which show how human activities pollute the environment.
- Pollution may be defined as addition of undesirable material into the environment as a result of human activities.
- The agents which cause environmental pollution are called pollutants.
- A pollutants may be defined as a physical, chemical or biological substance unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms.

TYPES OF POLLUTION

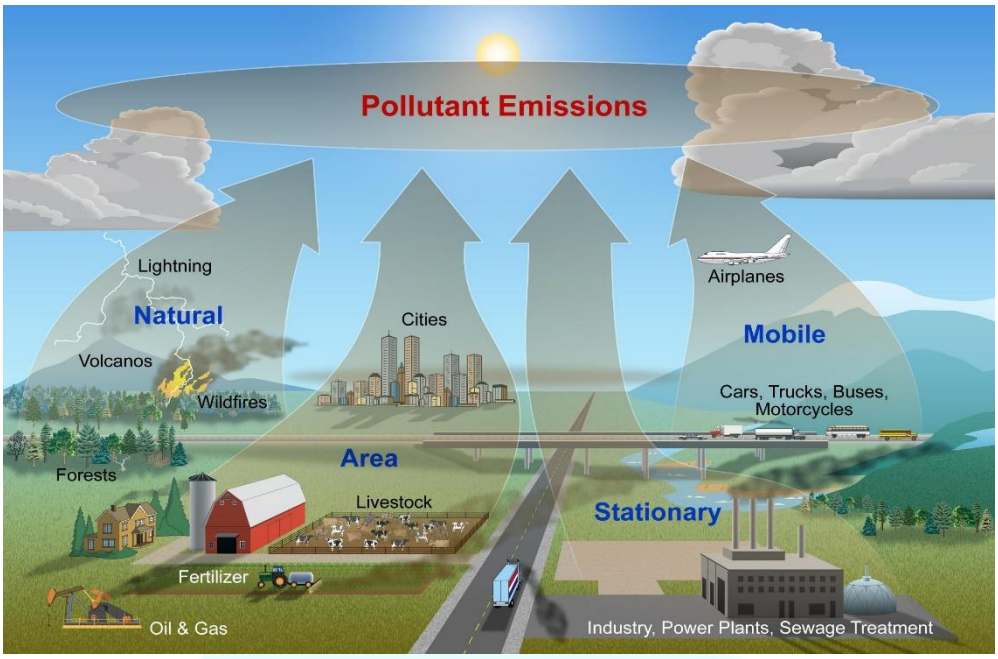
- Pollution may be of the following types:

1. Air pollution

2. Noise pollution
3. Water pollution
4. Soil pollution
5. Thermal pollution
6. Radiation pollution

1.AIR POLLUTION

- Air pollution is a result of industrial and certain domestic activity. An ever increasing use of fossil fuels in power plants, industries, transportation, mining, construction of buildings, stone quarries had led to air pollution.
- Air pollution may be defined as the presence of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere in such concentration that may be directly and indirectly injurious to humans or other living organisms, plants, property or interferes with the normal environmental processes.
- Air pollutants are of two types;
    a) suspended particulate matter
    b) gaseous pollutants like carbon dioxide (CO_2), NOx etc.
- Particulate air pollutants, their sources and effects Pollutant Sources Effects Suspended particulate Smoke from domestic, Depends on specific composition matter/dust industrial and vehicular soot Reduces sunlight and visibility, increases corrosion, Pneumoconiosis, asthma, cancer, and other lung diseases.
- Fly ash Part of smoke released from Settles down on vegetation, houses. Adds chimneys of factories and to the suspended participate matter (SPM) power plants in the air.



Particulate pollutants

- Particulate matter suspended in air are dust and soot released from the industrial chimneys. Their size ranges from 0.001 to 500 µm in diameter.
- Particles less than 10µm float and move freely with the air current. Particles which are more than 10µm in diameter settle down. Particles less than 0.02 µm form persistent aerosols.
- Major source of SPM (suspended particulate matter) are vehicles, power plants, construction activities, oil refinery, railway yard, market place, industries, etc.

Fly ash

- Fly ash is ejected mostly by thermal power plants as by products of coal burning operations.
- Fly ash pollutes air and water and may cause heavy metal pollution in water bodies.
- Fly ash affects vegetation as a result of its direct deposition on leaf surfaces or indirectly through its deposition on soil.
- Fly ash is now being used for making bricks and as a land fill material.

Lead and other metals particles

- Tetraethyl lead (TEL) is used as an anti-knock agent in petrol for smooth and easy running of vehicles.
- The lead particles coming out from the exhaust pipes of vehicles is mixed with air.
- If inhaled it produces injurious effects on kidney and liver and interferes with development of red blood cells.
- Lead mixed with water and food can create cumulative poisoning. It has long term effects on children as it lowers intelligence.
- Oxides of iron, aluminum, manganese, magnesium, zinc and other metals have adverse effect due to deposition of dust on plants during mining operations and metallurgical processes.
- They create physiological, biochemical and developmental disorders in plants and also contribute towards reproductive failure in plants.

Gaseous pollutants

- Power plants, industries, different types of vehicles – both private and commercial use petrol, diesel as fuel and release gaseous pollutants such as carbon dioxide, oxides of nitrogen and sulphur dioxide along with particulate matter in the form of smoke. All of these have harmful effects on plants and humans.

PREVENTION AND CONTROL OF AIR POLLUTION

Indoor air pollution :

- Poor ventilation due to faulty design of buildings leads to pollution of the confined space. Paints, carpets, furniture, etc. in rooms may give out volatile organic compounds (VOCs).
- Use of disinfectants, fumigants, etc. may release hazardous gases. In hospitals, pathogens present in waste remain in the air in the form of spores.
- This can result in hospital acquired infections and is an occupational health hazard.
- In congested areas, slums and rural areas burning of firewood and biomass results in lot of smoke.
- Children and ladies exposed to smoke may suffer from acute respiratory problems which include running nose, cough, sore throat, lung infection, asthama, difficulty in breathing, noisy respiration and wheezing.

Prevention and control of indoor air pollution:

- Use of wood and dung cakes should be replaced by cleaner fuels such as biogas, kerosene or electricity. But supply of electricity is limited.
- Similarly kerosene is also limited. Improved stoves for looking like smokeless chullahs have high thermal efficiency and reduced emission of pollutants including smoke.
- The house designs should incorporate a well ventilated kitchen.
- Use of biogas and CNG (Compressed Natural Gas) need to be encouraged.
- Those species of trees such as baval (Acacia nilotica) which are least smoky should be planted and used.
- Charcoal is a comparatively cleaner fuel. Indoor pollution due to decay of exposed kitchen waste can be reduced by covering the waste properly.
- Segregation of waste, pretreatment at source, sterilization of rooms will help in checking indoor air pollution.

Prevention and control of industrial pollution :

- Industrial pollution can be greatly reduced by:
  a) use of cleaner fuels such as liquefied natural gas (LNG) in power plants, fertilizer plants etc. which is cheaper in addition to being environmentally friendly.
  b) employing environment friendly industrial processes so that emission of pollutants and hazardous waste is minimized.
  c) installing devices which reduce release of pollutants. Devices like filters, electrostatic precipitators, inertial collectors, scrubbers, gravel bed filters or dry scrubbers are described below:
  - **Filters**
    - Filters remove particulate matter from the gas stream.
    - The medium of a filter may be made of fibrous materials like cloth, granular material like sand, a rigid material like screen, or any mat like felt pad.
    - Baghouse filtration system is the most common one and is made of cotton or synthetic fibres (for low temperatures) or glass cloth fabrics (for higher temperature up to 290oC).
  - **Electrostatic precipitators (ESP)**
    - The emanating dust is charged with ions and the ionized particulate matter is collected on an oppositely charged surface.
    - Environmental Issues are removed from the collection surface by occasional shaking or by rapping the surface.

- ESPs are used in boilers, furnaces, and many other units of thermal power plants, cement factories, steel plants, etc.

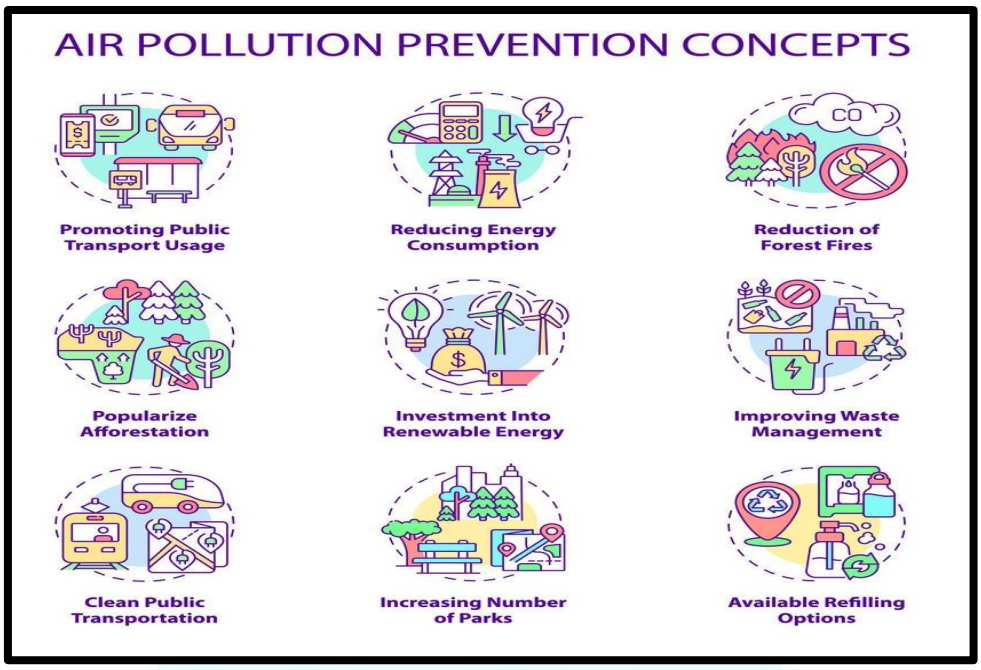
- **Inertial collectors**
  - It works on the principle that inertia of SPM in a gas is higher than its solvent and as inertia is a function of the mass of the particulate matter this device collects heavier particles more efficiently.
  - 'Cyclone' is a common inertial collector used in gas cleaning plants.
- **Scrubbers**
  - Scrubbers are wet collectors. They remove aerosols from a stream of gas either by collecting wet particles on a surface followed by their removal, or else the particles are wetted by a scrubbing liquid.
  - The particles get trapped as they travel from supporting gaseous medium across the interface to the liquid scrubbing medium.
  - Gaseous pollutants can be removed by absorption in a liquid using a wet scrubber and depends on the type of the gas to be removed e.g. for removal of sulphur dioxide alkaline solution is needed as it dissolves sulphur dioxide.
  - Gaseous pollutants may be absorbed on an activated solid surface like silica gel, alumina, carbon, etc. Silica gel can remove water vapour.
  - Condensation allows the recovery of many by products in coal and petroleum processing industries from their liquid effluents.

- Apart from the use of above mentioned devices, other control measures are;
  - increasing the height of chimneys.
  - closing industries which pollute the environment.
  - shifting of polluting industries away from cities and heavily populated areas.
  - development and maintenance of green belt of adequate width.

Control of vehicular pollution

- The emission standards for automobiles have been set which if followed will reduce the pollution.
- Standards have been set for the durability of catalytic converters which reduce vehicular emission.
- In cities like Delhi, motor vehicles need to obtain Pollution Under Control (PUC) certificate at regular intervals. This ensures that levels of pollutants emitted from vehicle exhaust are not beyond the prescribed legal limits.

- The price of diesel is much cheaper than petrol which promotes use of diesel.
- To reduce emission of sulphur dioxide, sulphur content in diesel has been reduced to 0.05%.
- Earlier lead in the form of tetraethyl lead was added in the petrol to raise octane level for smooth running of engines.
- Addition of lead in petrol has been banned to prevent emission of lead particles with the vehicular emission.



2.WATER POLLUTION

- Water Pollution is defined as any undesirable change in physical, chemical , or biological properties of water that may affect living beings adversely .
- Due to human activities , ponds , rivers , oceans , and estuaries are getting polluted in several parts of the world .

Sources of Water Pollution

- Discharge of untreated domestic sewage into rivers leads to water pollution.
- Excessive use of fertilizers and pesticides in agriculture also causes water pollution.

- Discharge of toxic waste from factories and refineries . etc . , pollute water.
- Oil spills that are an accidental release of oil by tankers in oceans may cause marine water pollution.
- Inappropriate disposal of litter such as plastic bags , wrappers and bottles , lead to Water Pollution .

Effects of Water Pollution

- Water Pollution affects both animals and plants and leads to an adverse impact on the aquatic ecosystem.
- The major effects of Water Pollution are the following –

1. Water - borne diseases :

- Sewage gives the maximum opportunity for the pathogenic and non - pathogenic microorganisms to grow.
- These pathogenic (disease - causing) microorganisms are responsible for several water - borne diseases like diarrhoea , typhoid , cholera , dysentery , jaundice , hepatitis , etc .

2.Toxic waste material:

- Toxic waste material from the industries such as heavy metals , pesticides , cyanides , and many organic and inorganic wastes are released directly into the river , lakes , and ocean , affecting the species present in these aquatic ecosystems , and ultimately affecting human health .

3. SOIL POLLUTION

- Soil Pollution is the build - up of persistent toxic compounds , chemicals , salts , radioactive materials , or disease - causing agents in the soil , which have adverse effects on plant growth and animal health .

Causes of Soil Pollution

- Soil Pollution is caused by the presence of man - made chemicals or other alterations in the natural soil environment.

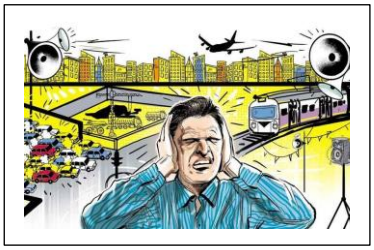
- This type of contamination usually arises from the rupture of underground storage links , application of pesticides , percolation of contaminated surface water to the subsurface , fuel dumping , leaching of wastes from landfills , or direct discharge of industrial wastes to the soil.
- The common chemicals involved are petroleum hydrocarbons , solvents , pesticides , lead , and other heavy metals.
- The occurrence of this phenomenon is correlated with the degree of industrialisation and intensities of chemical usage .

Effects of Soil Pollution

- Soil Pollution can have several harmful effects on ecosystems and human , plant , and animal health .
- The detrimental effects of soil pollution may come from direct contact with polluted soil or contact with other resources , such as water or food , grown on or come in direct contact with the contaminated soil .
- Some of the effects are :

1. Reduced soil fertility
2. Reduced nitrogen fixation
3. Release of pollutant gases
4. Release of radioactive rays causing health problems
5. Pollution of drinking water sources
6. Foul smell and release of gases
7. Waste management problems.

4. NOISE POLLUTION



- The unpleasant , discomfort - causing sound from any source is called noise . The sustained presence of harmful , unwanted , or annoying noise in the environment is called noise pollution .

Sources of Noise Pollution

- Any object that produces noise is a potential source of noise pollution . Examples are television and radio (when played at a loud volume) , air coolers , automobiles , blaring loudspeakers , and air conditioners .

Impacts of Noise Pollution

- Noise has a jarring effect on us . One should not underestimate the impact of noise pollution on people.
- Ear damage and loss of hearing (which may result from exposure to a sudden loud noise or from continuous exposure to noise over some time)
- Here are some of the harmful effects of noise pollution :

1. Irritation and loss of concentration ;
2. Sleep disturbance and stress (which can lead to high blood pressure) ;

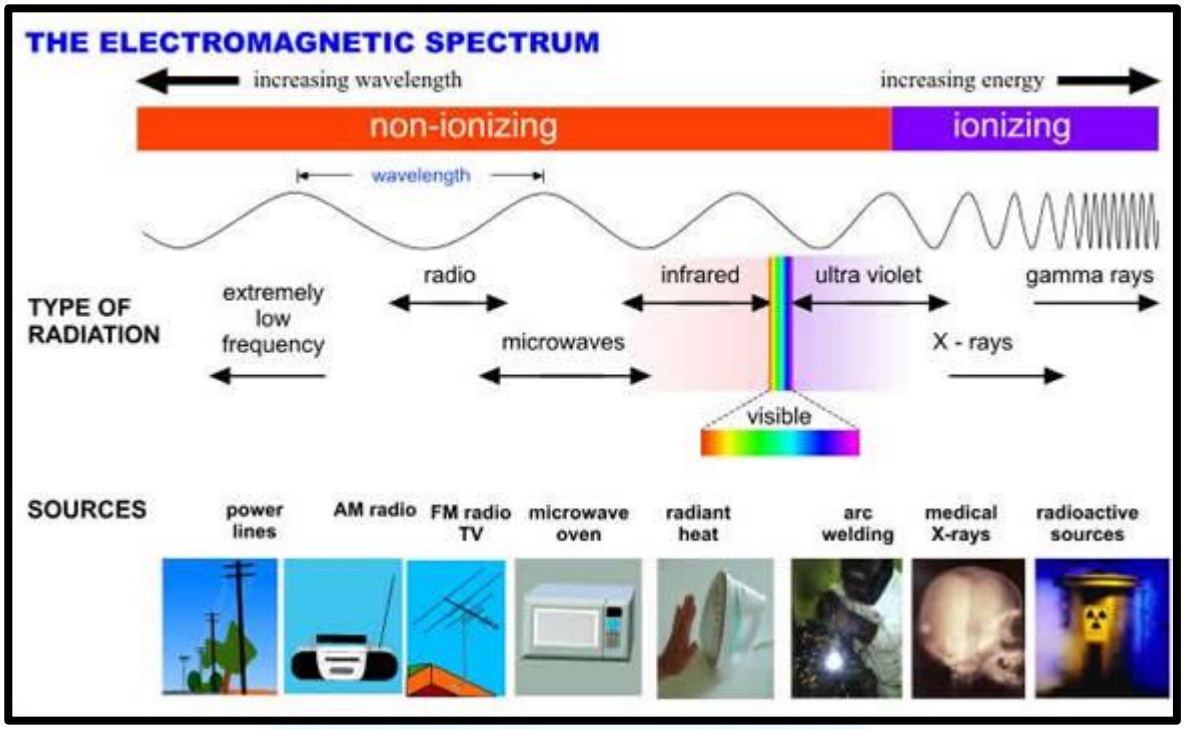
Measures to Reduce Noise Pollution

- Minimising noise pollution requires a certain degree of discipline from all of us . While driving , people should avoid playing loud music and using the horn unnecessarily. Some of the measures one should adopt to keep noise pollution under control are given below :

1. The use of loudspeakers should be avoided .
2. People living in flats (and houses close to each other) should not talk too loudly or play the television / music too loudly so as not to disturb their neighbours .

5. RADIOACTIVE POLLUTION

- This is considered one of the most dangerous pollution because of its permanent effects .
- An unarrested upset in a nuclear plant , careless nuclear waste disposal , etc . It can cause cancer , skin , blood , infertility due to exposure , birth defects, and blindness ;
- It can permanently change the soil , air , and water – The major sources of life . It can even cause mutation in species which can propagate for ages .
- Now students must have already understood environmental pollution and its effects on health .



6. CLIMATE CHANGE

- Many activities have contributed to a significant change in the climate temperature.
- The heat gain from air - conditioning units, vehicles on the road and other combustion processes will increase the rate of depletion of the ozone layer , increasing climate temperature . A second problem is the so - called greenhouse effect.
- Carbon dioxide in the atmosphere functions like the glass in a greenhouse , screening out excessive infrared rays and acting as an insulator to prevent heat from escaping day and night.
- Without the protection of the atmosphere , the temperature on the earth could reach the extremes they do on the moon.
- If we continue to burn fossil fuels , the level of carbon dioxide in the air may increase to the point where it will blanket the earth and cause it to warm to a dangerous level.

Environmental Pollution and Its Effects on Health

1. Air Pollution results are Cancer , neurobehavioral disorders , cardiovascular problems , reduced energy levels , premature death , asthma , irritation of the eyes , nose , mouth and throat , reduced lung functioning , respiratory symptoms , etc.

2. Nutrient polluted water causes overgrowth of toxic algae eaten by other aquatic animals and may cause death ; it can also cause eruptions of fish diseases.
3. Chemical contamination can cause declines in frog biodiversity and tadpole mass.
4. Oil Pollution can increase susceptibility to disease , affect reproductive processes , and negatively affect the development of marine organisms . It can also be a source of gastrointestinal irritation , damage to the nervous system , liver and kidney damage.
5. Mercury in water can cause reduced reproduction , slower growth and development , abnormal behaviour and death .
6. Persistent organic pollutants may cause declines , deformities , and death of fish life . Fish from polluted water and vegetable / crops produced or washed from contaminated water could also impact human and animal health .

Environmental Pollution Prevention

- Students already know about environmental pollution definition and its effects . Now let us check out how to prevent environmental pollution .

1. Environmental Pollution can be controlled by proper waste management and developing green chemistry . Instead of conventional fuels and energy systems , non - conventional fuels and non - conventional energy systems must be put into practice . This will cause less pollution .
2. The growth of the population must be controlled.
3. Forests should be grown . Everybody must plant a tree and must protect it.
4. Every citizen should feel the social responsibility of protecting and keeping the environment clean and green .

- Pollution impacts the quality of life and harms biodiversity . Fresh air , water and soil is always the first certificate for survival on this planet.
- The government and citizens must have collective responsibility for preventing and controlling environmental pollution .
- Although people do not have enough resources to repair the damage caused by environmental pollution , the prevention will gradually show improvements .
- We should try to work together to end pollution and build a comfortable environment.

SUCCESSION

- A community builds up over a period of Time. As the time passes communities change.
- In a community there are interactions among the organisms (biotic factors) and between the biotic and abiotic factors (climate, light, soil excetra. All these bring about changes in a community.
- A community is a dynamic unit where trophic levels exist there is a flow of energy and cycling of nutrients. it is a living part of an ecosystem.
- The wind, fire, volcanic activity or any other event in nature or even man may destroy the organisms living in an area. Now if this area is left alone a succession would start and ultimately a permanent community would take the shape.
- This process from the beginning to the climax may take many years. During this time there will be an orderly and progressive replacement of one community by another till a relatively stable community is established. This is called ecological succession.
- A complete succession is called sere. A sere i is made up of a number seral stages. A climax community is the final over the last seral stage.

Certain important terms related to succession

1) Primary succession - succession occurring on a previously unoccupied site like a volcano rocks or glacial region.

2) Secondary succession - succession occurring on the regions where natural vegetation has been destroyed or removed . it refers to the reappearance and the establishment of communities like after deforestation.

3) Pioneer species - Refers to the first plant species that colonies or occupy the area.

4) Pioneer community - Various pioneer spieces together form The pioneer community.

5) Seral stages - There are intermediate stages from Pioneer to climax community. Each Seral stage is replaced by another Seral stage in succession. Each seral stage has its particular communities calle seral communities.

6) Late successional species -These are the species which get established later , during the course of succession.

7) Climax community - It refers to the last stage of succession after seral communities.

8) Sere - the different seral stages of succession together constitute is a sere.

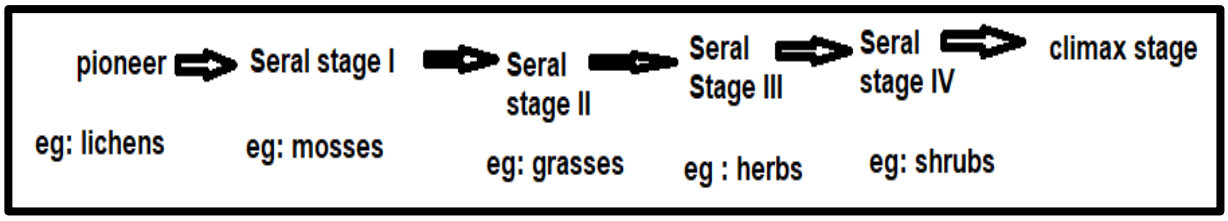
9) Hydrarch succession - succession occurring in water bodies like ponds and lakes.

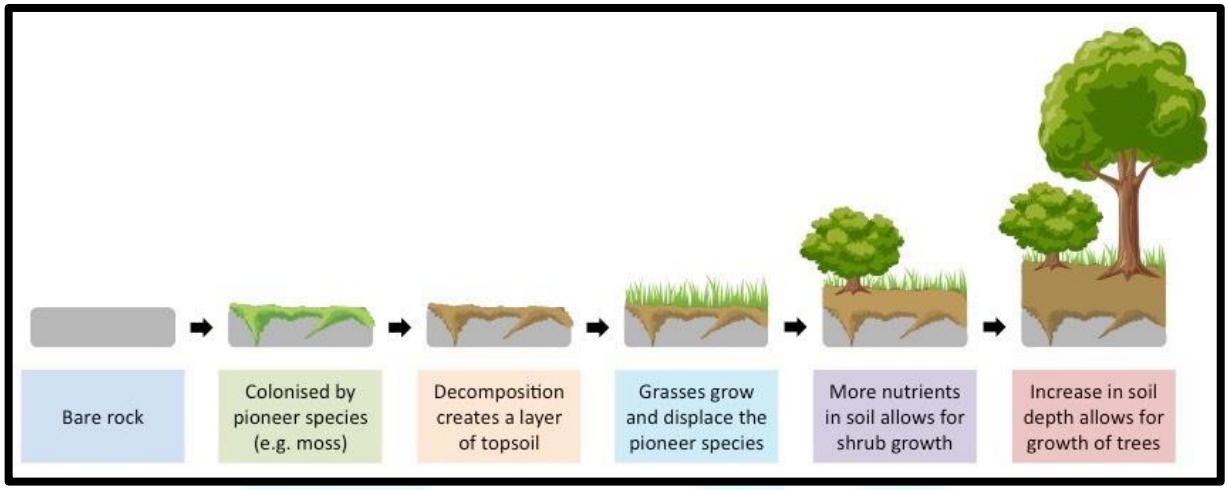
10) Xerach succession - Succession occurring in dry and hot terrestrial areas in dry or low moisture conditions like sand dunes, bare rocks etc.

PROCESS OF SUCCESSION

- The first organisms that colonise a bare area called pioneers. After having adjusted to the environment , they begin to multiply. Normal pioneer species show high rate of growth but short life spain.
- Initially there is no competition for pioneer s but with time, the competition results in the decrease in their number also. With time , the number of pioneers decreases due to the changes in environment and competition.
- As the pioneers die and decay , they add organic matter, moisture and nitrogen to soil. In this enriched soil next group of communities thrive well.
- They constitute one seral stage in succession. By their activities they modify the environment, the changed environment becomes unsuitable for their growth, and a new group of plants and animals invade the environment, forming next seral stage.
- This way an orderly progression goes on , with progressive replacement of one community by another till a climax or stable stage is reached. The intermediate stages from pioneer to climax community are called seral stages.

Seral stages





Kinds of ecological succession

1. Primary succession.
2. Secondary succession

PRIMARY SUCCESSION	SECONDARY SUCCESSION
It occurs in an area where no community had existed before	It occurs in an area where a community existed before
Lichens are the first organisms to appear	Grasses , shrubs and weeds are the first organisms to appear
It may take very long about 1000 years to reach the climax community	It takes a shorter time about 50 -100 years for a grass land about 200 years for a clear forest to reach climax community
It begins on bare rocks , sand dunes, volcanic islands , lava flows etc.	It begins on an area devastated by fire, earth quake or forest cleared by man.

ENTRI

CHANGES IN ECOSYSTEM DURING SERAL STAGE AND CLIMAX CHANGE

SERAL STAGE	CLIMAX STAGE
Size of individuals is small, (for example herbs and shrubs are smaller plants)	Size of individuals is large (for example trees are larger plants)
Ecological niches are few and generalised	Ecological niches are many and specialised.
Community organisms is simple due to fewer number of organisms and few niches	Community organisms is complex.
Food chains and food webs are simple	Food chains and food webs are simple complex.
Efficiency of energy use is low	Efficiency of energy use is high
Low nutrient conservation	High nutrient conservation

DIFFERENCE BETWEEN PIONEER COMMUNITY AND CLIMAX COMMUNITY

PIONEER COMMUNITY	CLIMAX COMMUNITY
The first community that invades the bare rock or pond in succession	The last community of succession
Species have high rate of growth and short life span	Species are slow growing and long lived
Pioneer community is replaced by another community with different species composition	A stable community . Does not show changes in species composition

In a xerarch (lichens and hydrarch), the phytoplanktons are pioneer communities	Climax community is dominated by large trees.

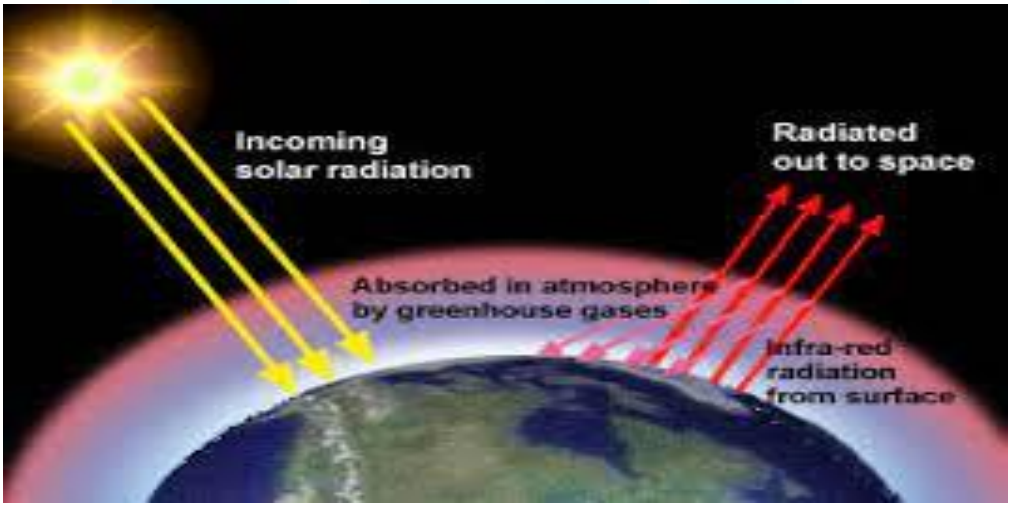
DIFFERENCE BETWEEN SOME IMPORTANT TERMS

TERM	CHARACTERISTICS
ECOTONE	Refers to plane or zone where two communities meet and blend together.
EDGE EFFECT	Refers to the tendency of increased variety and density of life at the community borders in the transaction area (called ecotone)
KEYSTONE SPECIES	Have strong effect on the abundance of other species. Play an important role in community composition. Generally found in low abundance. E.g: Fig trees in tropical rainforests
CRITICAL LINK SPECIES	Acts as a link between a number if species. Play an important role in absorption of nutrients, pollination of flowers etc. Generally found in high abundance. Eg. Mycorrhizae
ECTOPARASITES	Parasites that are attached to the external surface of the body of the host (ie present outside the host). Generally attached to the skin and hair if the soil.
ENDOPARASITES	Parasites that are present inside the body of the host. Present in the digestive tract , blood or lymph of the host.

THE GREENHOUSE EFFECT AND GLOBAL WARMING

THE GREENHOUSE EFFECT

- The earth's temperature is maintained by the balance of incoming and outgoing solar radiation. Radiations from sun pass through the atmosphere and they are reflected back into space.
- The atmosphere acts like the window glass pane of a gigantic greenhouse surrounding the earth.



EFFECT OF GREEN HOUSE GASES ON EARTH's TEMPERATURE

- The mean annual temperature of earth is about 15 ℃. In the absence of greenhouse gases in the atmosphere , the earth's , mean temperature would be around - 20 ℃. More concentrations of greenhouse gases means more temperature of earth.

ENHANCED GREENHOUSE EFFECT

- Human activities have always had an effect on the climate. But with the industrialisation of many parts of the planet, the effects have multiplied.
- The industrial activities release tons of CO_2 into the atmosphere, along with hundreds of millions of tons of other " green house gases" such as methane and the chloro - fluro carbon , as a result their presence in the atmosphere has increased tremendously.
- Forest fires also contribute considerably to the emission of "green house gases". Once released into the atmosphere , CO_2 remains there for a period of between 50 and 200 years.
- CH4 on the other hand , remains for only 10 years, but can absorb between 20 nad 30 times as much heat as CO_2.
- The excessive increase in the concentration of green house houses in the atmosphere would remain more and more if the infra - red radiations, resulting in the enhanced greenhouse effect.
- This makes the temperature of the earth's crust increase above the limits of the natural variations. Detailed scientific analysis have shown that the average global temperature of the Earth's surface has increased by 0. 5 degrees in the last 100 years.
- Of emissions of " greenhouse gases" continue increasing at their current rate, then by the middle of the next century the temperature could reach the highest level in the last 20, 000 years affecting the weather and climate of the world.

GLOBAL WARMING

- As a result of enhanced greenhouse effect, the consequent increase in the global mean temperature is called global warming.
- The Intergovernmental Panel on Climate change IPCC periodically makes an assessment of the abundance of green house gases in the atmosphere and their possible impact on climate and related issues.

RELATIVE ABUNDANCE OF GREEN HOUSE GASES

- The trends in the increase in concentrations of greenhouse gases since pre - industrial times are briefly described below.

a. CARBON DIOXIDE (CO_2)

- The most abundant green house gas in the atmosphere.
- Its level has increased by 31 % due to industrialisation since 1750.
- The increase is largely due to fossil burning , deforestation and change in land use.

b. METHANE (CH_4)

- Methane concentration has more than doubled since 1750 as a result of industrialisations.
- Methane is basically a product if incomplete decomposition . It is produced by a group of bacteria called methanogens under anaerobic conditions.
- Major source of Methane includes are;
  - ☆ Fresh water wet lands
  - ☆ Enteric fermentation in cattle
  - ☆ Flood rice fields
  - ☆ Bio mass burning

c. NITROUS OXIDE (N2O)

- Concentration of N_2O in atmosphere has increased by 17 % due to industrialisation. Main sources of N_2O are;
  - ☆Agriculture
  - ☆Bio mass burning
  - ☆Industrial process
  - ☆Burning of nitrogen rich fuels
  - ☆Livestock waste
  - ☆Breakdown of nitrogen rich fertilizers in soil
  - ☆Nitrated contaminated ground water

d. CHLOROFLUOROCARBONS (CFC)

- CFCs are non toxic , non inflammable , highly stable and synthetic gaseous compounds if carbon and halogens (chlorine and fluorine).
- Use of CFCs and hydrofluorocarbons (HFCs) began in 20th century only, and in a short span if time they have made a significant impact in global warming.

ENTRI

MAIN SOURCE OF CFCs AND HCFs

- Propellants in aerosol sprays
- Air conditioners and refrigeration units
- Solvents in industrial units (like cleaning agents)
- Production of plastic foam (styrofoam) for packing of food etc.

EFFECTS OF ABUNDANCE OF GREENHOUSE GASES

- The increase in the concentration of greenhouse gases have the following possible effects.
- CO_2 ‘ fertilisation effect’ on plants.
- Global warming.
- Depletion of ozone layer in stratosphere.

STRATEGIES ABUNDANCE OF GLOBAL WARMING

- Though the extent and exact effects of global warming are debatable, scientists generally agree that we should plan certain strategies to cut the emission of green house gases. Some important strategies could be as mentioned below;

a. Reducing the use of fossil fuels that we burn. We can make a big differences by improving the efficiency of heating systems and by reusing ‘waste’ heat from industry.

b. Also we should develop alternative renewable sources of energy (like wind , water and solar energy)

c. Increasing the forest and vegetation cover- This would increase photosynthetic utilisation of CO_2. we would limit the destruction of forests and use methods of agriculture that do not damage the land.

d. Minimising the use if nitrogen fertilisers in agriculture to reduce N_2O emission.

e. Developing substitutes for CFCs.

ENTRI

STRATOSPHERE OZONE DEPLETION

- Formation of ozone layer O_2 in stratosphere.
- In the stratosphere , the ultra violet (UV) radiations cause two processes to occur simultaneously , the destruction of ozone and the formation of ozone.
- Photodissociation of ozone into O_2 and O.

$$O_3 \Longleftrightarrow O_2 + O \text{ (destruction of ozone)}$$

- O_2 and O quickly recombine to form O_3

$$O_2 + O \Longleftrightarrow O_3 \text{ (formation of ozone)}$$

- The net result is that equilibrium is established and a steady state of concentration of ozone layer is established.
- Concentration of ozone layer changes with seasons.
- Concentration is higher - during February – April.
- Concentration is lowest - during July – October.
- Ozone layer acts as a protective shield, the ozone shield. It absorbs the harmful UV radiations from reaching the earth.
- Absorption of UV radiation increases exponentially with the thickness of ozone layer.
- And so, since the thickness of ozone is more at poles, and less at equator, less UV reaches the pole as compared to equator (or topics).

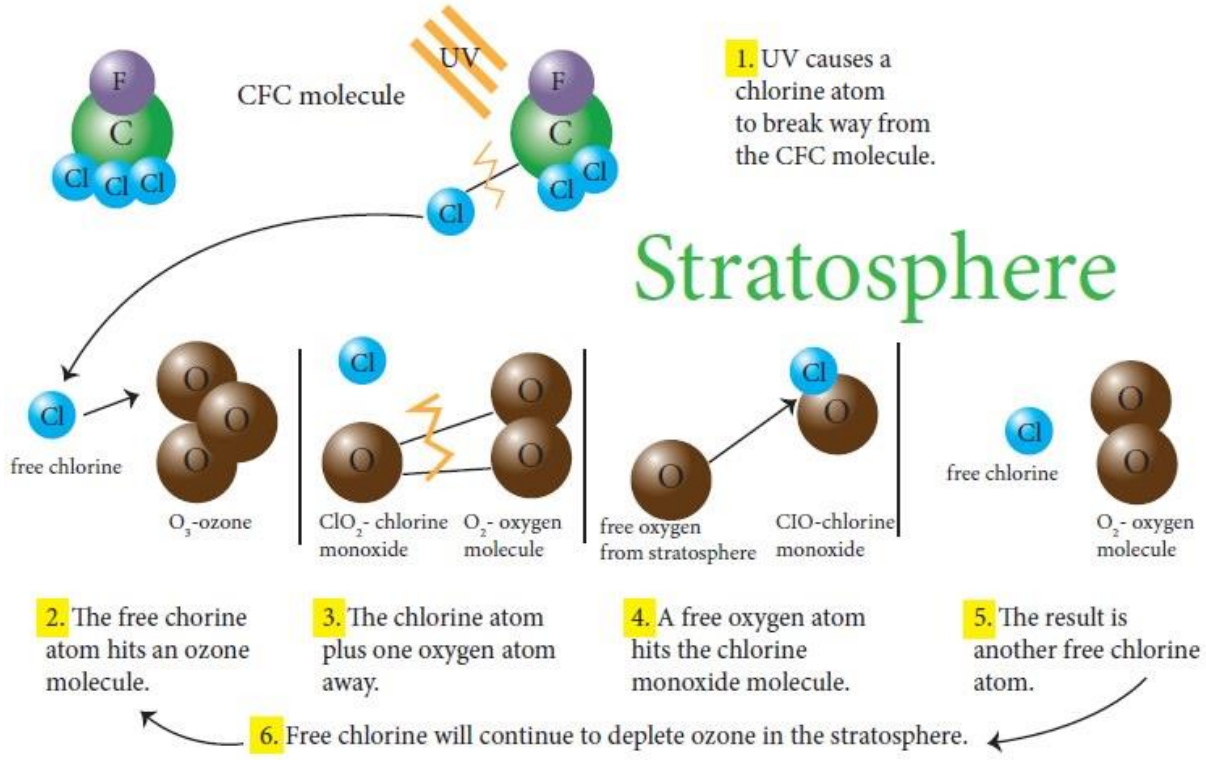
OZONE HOLE

- For decades NASA satellites have tracked the extent of ozone depletion over Antarctica.
- Every year since 1975 an ‘ozone hole’ appears in August when sunlight triggers chemical reactions in cold air trapped over the southpole over Antarctica winter.

- The hole intensifies during September before tailing off as temperature rise and in November and December.
- In September 2000, the ozone hole covered an area of 11.4 million square miles, 3 times the size of United States.
- It extended over the of city of Punta Arenas in Southern Chile with a population of about 120,000 people, exposing them to very high levels of UV radiation.

CAUSE OF OZONE DEPLETION

- The gases CFCs, CH_4 and N_2O escape into the stratosphere and cause destruction of ozone (O_3). Out of these gases, CFCs rise up through the atmosphere and produce 'active chlorine' (Cl and ClO) radicals, which reduce ozone (O_3) into oxygen O_2 .
- CFC molecules can stay in the stratosphere for about 100 years. One chlorine atom from a CFC molecule could destroy 100,000 ozone molecules in the following mechanism.
- UV radiation causes CFCs to release Cl atoms.
- UV radiation also act on O_2 to release oxygen free radicals.
- Cl atoms and O free radicals react with ozone to form oxygen.
- destruction of ozone molecules and converting ozone into oxygen.



POPULATION

- It is a GEOGRAPHICALLY ISOLATED group of the individuals of the same kind (so called species).
- It is a group of organisms of the same species that occupy a specific area.
- The population may be closer or widely dispersed geographically.
- The number of population distributed over a large geographical area may form one species.

POPULATION CHARACTERISTICS

- In studying population, we are concerned not just with the number of a given species living in a given area at a given moment of time, but rather an understanding of how population grows are maintained, or declined in response to the environment.
- To study population, we need to focus on properties of a group rather than an individual. In doing so we examine various characteristics of population like:
  1. Population density
  2. Natality

3. Mortality
4. Dispersal
5. Age distribution
6. Biotic potential

Population density : it is expressed as the total number of individuals present in an area or volume at a specific given time.

D = N/S

D = population density

N = number of individuals of a species.

S = unit of space = area at a particular time.

S is taken as m^2 (1m X 1m) in case of terrestrial organisms like counting the organisms in a quadrate (m^2) of soil. S is taken as m or (1m X 1m X 1m) in case of aquatic organisms or the ones suspended in a medium.

- Population density of a species varies from time to time and area to area. For example, there may be greater density of plants during rainy season as compared to the dry season.
- A number of factors like available resources, natality, mortality, age distribution etc affect the population density.

NATALITY

- It refers to the production of new organisms in a population. It is also known as BIRTH RATE.
- It depends on a number of factors like the number of females, the favourable conditions like food and space, vegetatative propagation and germination etc.
- NATALITY RATE it refers to the increase in individuals per unit of time.

MORTALITY

- It is also referred as the DEATH RATE. It is decrease in a population by death by death of individuals.
- It depends on the number of ageing individuals or conditions like scarcity of food or enemies etc.

- MORTALITY RATE is expressed as the number of individuals dying over a time period.

DISPERSAL

- The majority of organisms disperse at one time or the other during their life cycles. Dispersal may be in the form of immigration, emigration or migration.

IMMIGRATION

- The INWARD MOVEMENT with no going back of the individuals. It generally occurs during favourable conditions. When there is enough space, water and nutrients the individuals from neighbouring population move in the settle there.

EMIGRATION

- The OUTWARD MOVEMENT with NO RETURN of the individuals. It is generally during UNFAVOURABLE conditions like shortage of food and space, destruction of habitat, flood or drought.

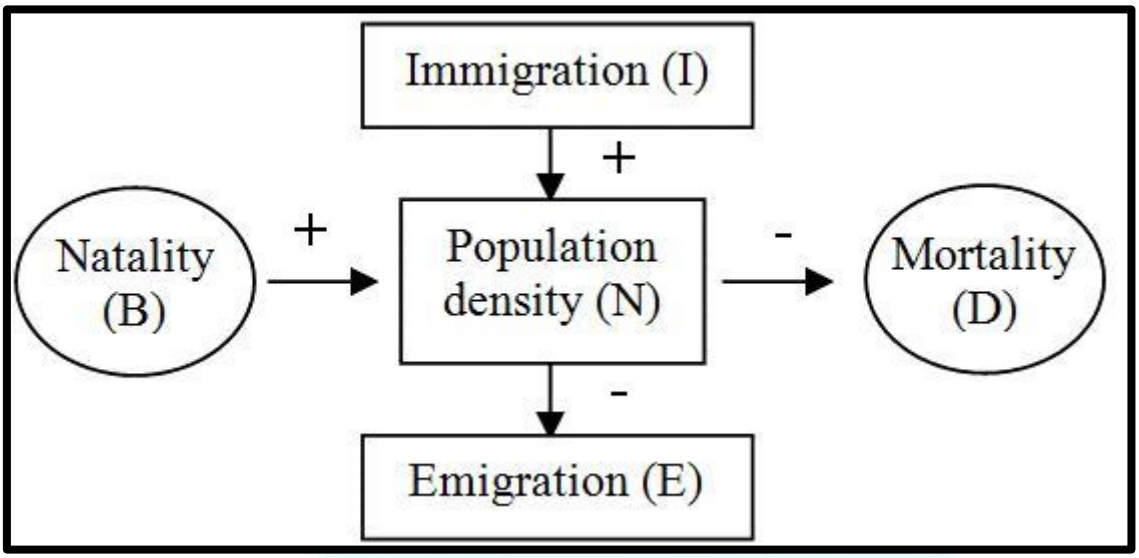
MIGRATION

- It is a TWO WAY PERIODIC MOVEMENT which occurs by mass movement of the entire population during unfavourable conditions like cold and hot seasons and the return of the same when the conditions become favourable. It does not determine the size of a population.
- The active immigration, emigration and migration are concerned only with the animal population that move about. For land plants, it could be only arrival of seeds by wind or current, water or by the movement of animals.

AGE DISTRIBUTION

- A population contains individuals of varying age. Three ages that are referred as ecological ages are,
  1. Pre reproductive
  2. Reproductive
  3. Post reproductive

- Depending on which age group is more prevalent in a population, the population could be expanding, stable or declining.
    1. Population with more young members ……. Expanding population. Or pre - reproductive age group.
    2. Population with almost same number of ……. Stable population. Young and older age group.
    3. Population with large proportion of older ……. Declining population. Individuals and less pre - reproductive group.
- The natality (birth) and mortality (death) are also linked to the age structure in a population.



BIOTIC POTENTIAL

- It is the physiological capacity of the organisms to produce offsprings.
- It is also known as reproductive potential.
- The biotic potential is far more than the surviving organisms.
- The maximum value of biotic potential is not obtained due to many factors in the environment such as,
    A. Shortage of food.
    B. Premature death due to infection of diseases.
    C. Decrease in number due to predation of organisms.
- The biotic potential is realised only when environmental conditions are favourable and not limiting. Then the natality rate is maximum and mortality rate is minimum.
- Biotic potential is designated as symbol ‘r’.

ENTRI

ENVIRONMENTAL RESISTANCE

- It refers to the sum of different environmental factors that do not permit survival of all the members of a species and keep a check on the population size or its biotic potential.
- With increase in population size, the environmental resistance (against the population) increases.
- Environmental resistance includes the limiting effect of both abiotic and biotic factors mentioned below that do not allow the organism to attain biotic potential and keep the population size at a much lower level.

ABIOTIC FACTORS

- Daily duration of sunlight, temperature, rainfall, humidity, kinds of soil, wind direction etc.

BIOTIC FACTORS

- Generally food relationships like predator - prey, producer - consumer or host - parasite (disease causing pathogens) affect the population density.

POPULATION GROWTH

- It refers to the growth of population over a period of time.
- Population growth = Organism added - Organism lost.
- Organism tagged are determined by,
    1. Natality or birth rate (B) and
    2. Immigration (I) ie. number added by permanent settlement of individuals from other areas.
- Organism lost are determined by,
    1. Mortality or death rate (D) and
    2. Emigration (E) ie. number moving out and settling in other areas permanently.
- Depending on the organisms added or lost, population takes different forms as specified below.
- If the organisms added are MORE THAN the organisms lost = It leads to increase in population.
- If the organisms added are LESS THAN the organisms lost = It leads to decrease in population.

- If the organisms added are EQUAL TO the organisms lost = It leads to zero population growth (ZPG).
- Population growth can be measured as the increase in population size over a period of time. Suppose initial population size is smaller 0.
- Population size after interval of time t = N_T
- Then N_T = Initial population size + population growth
  = N_0 + (Organisms added - Organisms lost)
  = N_0 + (B + I - D - E)
  - Where B = Birth rate / natality
    I = Immigration
    D = Death rate / mortality
    E = Emigration

SPECIES INTERACTIONS - INTERSPECIFIC INTERACTIONS

- When various species live together in a community, number of interactions take place according to specific needs of food, shelter and habits. These interactions can be of two main types,
  (i) intraspecific and
  (ii) interspecific.
- The intraspecific interactions are the interactions between the members of the same species while the interspecific interactions are between the members of two different species. In this chapter, we will study only about various types of interspecific interactions.

- These interactions can be broadly classified into two main categories depending on the type of effect they have on the interacting organisms.

1. Positive or beneficial interactions.
2. Negative or inhibition interactions.

Interspecific interactions

A. Positive interactions.

B. Interaction in which one or both the species are benefitted.

1. Mutualism (Both species get benefitted).
2. Commensalism (One species gets the benefit, other is neither harmed nor benefited)

B. Negative interactions

- Interactions in which one or both the species are harmed or have adverse effects.
    1. Competition (Both species compete for the same resources).
    2. Predation (Predator feeds on the prey).
    3. Parasitism (Parasite draws nourishment from host).

A. Interactions with positive effect

- These are the interactions between different species in which one or both species are benefited. Here we will discuss two such interactions. These are:
    1. Mutualism
    2. Commensalism

B. Interactions with negative effects

- These are the interactions between different species in which one or both species are harmed. Even if one species is benefited, it is at the cost of the other i.e. the other species is harmed. In this chapter we will study the following negative interactions.
    1. Competition
    2. Predation
    3. Parasitism