XII
BOTANY
FOCUS AREA NOTE
2020 - 2021

Prepared by

Botany Team, TVPM

Chapter – 1
REPRODUCTION IN ORGANISMS

Asexual reproduction:

Offsprings produced by single parents.

Without involvement of gamete formation

Offsprings are genetically identical to their parents (Clones).

Methods of asexual reproduction:

Cell division as a method of asexual reproduction as in Protista and Monera.

- Binary fission e.g. *Amoeba*, *Paramecium*.
- Budding: e.g. yeast.

Types of asexual reproductive structures/methods

Methods/Structures of asexual reproduction	Organisms
Binary fission	***Amoeba, Paramecium***
Buds	***Hydra***
Budding	***Yeast***
Zoospores	***Chlamydomonas***
Conidia	***Penicillium***
Gemmules	***Sponges***

Vegetative propagation units in plant: (Vegetative propagules)

Vegetative Propagule	Plant
Rhizome	***Ginger, Banana***
Bulb	***Onion, Garlic***
Stem tuber (Eye buds)	***Potato***
Offset	***Eichhornia***
Bulbil	***Agave***
Leaf buds (Adventitious buds)	***Bryophyllum***

Gametogenesis

- Process of gamete formation is **gametogenesis**.
- Two gametes are similar in appearance are called **homogametes (isogametes).**
- Gametes produced are of two morphologically distinct types called **heterogametes.**
- Male gamete is called **antherozoids** or **sperm** and the female gamete is called **ovum** or **egg**.

Sexuality in organism:

- Plant having both male and female sex organ called **homothallic** or **monoecious.**
- Plants having only one sex organ is called **heterothallic** or **dioecious.**
- In flowering plants, the unisexual male flower is **staminate**, i.e. bearing stamens, while the female is **pistillate** or bearing pistils.
- Animal having one type of reproductive system, called **unisexual** (cockroach, human).
- Animal having both male and female reproductive system, called **hermaphrodite** or **bisexual**(earthworm, sponges, tapeworm etc.)**.**

✯Gametes are always **haploid**(having half set of chromosome), although organisms may be haploid and diploid. Diploid organisms form gametes by meiotic division. The organisms belonging to algae, fungi, and bryophytes have haploid plant body and pteridophytes, gymnosperms, angiosperms and most of animals are **diploid** (having double set of chromosome).

✯In diploid organisms, gamete mother cell **(meiocyte)** undergoes meiosis in which one set of chromosome is present in gametes.

Fertilisation

- The fusion of male and female gamete is called **fertilization or syngamy.** It results in the formation of diploid zygote.
- The process of development of new organisms without fertilisation of female gametes is called **parthenogenesis**.

  Eg :- Honey bee, Rotifers and Lizards

EXTERNAL FERTILIZATION

- Fertilization occurs outside the body of the organism Large numbers of gametes are released in the surrounding medium.

  Eg :- Bony fishes and Amphibians.

INTERNAL FERTILIZATION

- **Fertilization** occurs inside the body of the organism Numbers of ova produced are less, but large numbers of male gametes are released and they travel towards the ovum.

  EG :-. Birds and Mammals

Chapter – 2
SEXUAL REPRODUCTION IN FLOWERING PLANTS

Structure of microsporangium:

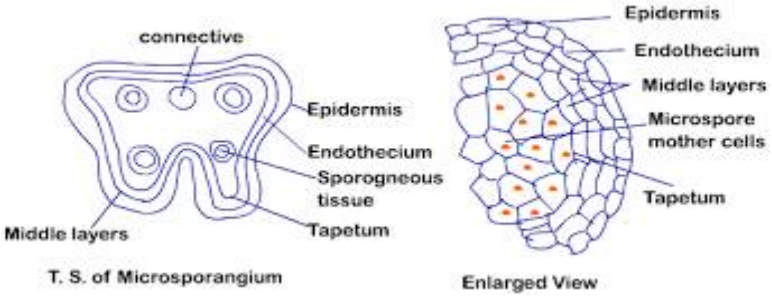
Each **microsporangium** surrounded by four wall layers

- **Epidermis** – Outermost layer provide protection.
- **Endothecium:**

  contains radially elongated, compactly arranged hygroscopic cells which helps in the protection and dehiscence of anther.
- **Middle layer** – multilayered and provide protection.
- **Tapetum.**

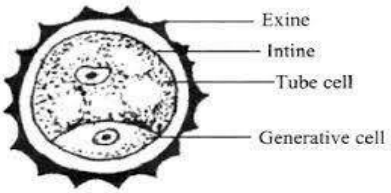
  The innermost layer is **tapetum** which is multinucleated, with dense cytoplasm; it nourishes the developing pollen grains.

  The centers of each microsporangium contain homogenous cells called **sporogenous tissues.**



Pollen grain:

- Pollen grain represents the **male gametophytes**.
- It is spherical and measuring about 25-50 micrometer in diameter.
- It is covered by **two layers**.
- The hard outer layer called the **exine** is made up of **sporopollenin,** which is the most resistant organic material. It can withstand high temperature and strong acids and alkali. No enzyme can degrade sporopollenin.



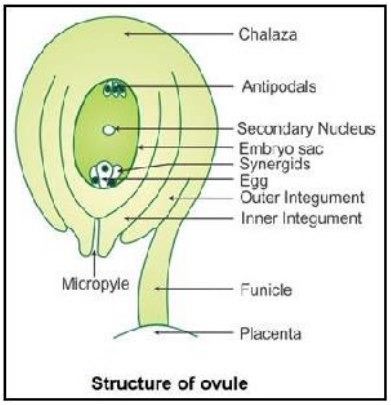
Pollen grain (Sectional view)

- The exine has prominent apertures called **germ pore** where sporopollenin is absent.
- The inner wall of pollen grain is called **intine.** It is thin and continuous layer made up of **cellulose** and **pectin**.
- On maturity, the pollen grain contains two cells, the **vegetative cell** and **generative cell**.
- The vegetative cell is bigger, has abundant food reserve and a large irregularly shaped nucleus.
- The generative cell is small and floats in the cytoplasm of vegetative cell.
- In 60% of angiosperms, pollen grains are shed at this **2-celled stage**.
- In others the generative cell divides mitotically to form two male gametes and pollen grain are usually shed **3-celled stage.**

The Megasporangium (Ovule):

- Ovule is a small structure attached to the placenta of locule with a stalk called **funicle.**
- The body of the ovule fused with the funicle in the region called **hilum.**
- **Hilum** is the junction between the funicle and ovule.
- Each ovule has one or two protective envelops called **integuments**.

- Integument covered the ovule except an opening at the tip called **micropyle**.
- Opposite of the micropylar end, is the **chalaza**, representing the basal part of the ovule.



Structure of ovule

Megasporogenesis:

- The process of formation of **megaspores** from the **megaspore mother cell (MMC)** is called **megasporogenesis.**
- In the center of the ovule there is a mass of tissue called **nucellus**.
- Cells of nucellus have abundant reserve food materials.
- One cell of the nucellus towards micropylar end differentiated into **megaspore mother cell** (MMC).
- It is a large **diploid cell,** dense **cytoplasm** with **prominent nucleus.**
- The MMC undergo **meiotic** division resulting four haploid **megaspores**.

Female gametophyte:

- Out of four megaspores, one megaspore is functional and other three degenerates.
- The functional **megaspore** developed into the **female gametophyte.**
- Female gametophyte is known as the **embryo sac**.
- Development of embryo sac from a single megaspore is called as **monosporic development**.
- The nucleus of the functional megaspore divided by **mitotic division** to form **two nuclei** which move to the opposite poles, **2-nucleated embryo sac**.
- Two successive mitotic division leads to formation of **4-nucleate** and later **8-nucleate** stages of the embryo sac.
- All mitotic divisions are free nuclear type; **karyokinesis** is not followed by **cytokinesis.**
- Six of the eight nuclei are surrounded by cell walls and organized into cells.
- Three cells are grouped together at the micropylar end, constitute the **egg apparatus.**
- The egg apparatus, in turn consists of two **synergids** and one **egg cell**.
- Synergids have special **filiform apparatus**, which play an important role in guiding the entry of pollen tube into the synergids.
- Three cells arranged towards chalazal end are called **antipodal** cells.
- The large **central cell** has two **polar nuclei.**
- A typical angiosperm embryo sac at maturity is **8- nucleated** and **7-celled.**

Pollination:

- Transfer of pollen grains from the anther to the stigma of a pistil is termed as pollination.
- Both male and female gametes are non-motile.

Kinds of pollination:

1. **Autogamy:**
   Pollination within same flower.
   In open and exposed anthers and stigma autogamy is rare.

Viola, Oxalis **and** ***Commelina*** produce two types of flowers:

- **Chasmogamous**: Flowers with exposed anther and stigma.
- **Cleistogamous**: Flowers with enclosed anther and stigma.
  Cleistogamous flower is invariably **autogamous** and **assured seed** set even in the absence of the pollinator.

2. **Geitonogamy:**
   Pollination between two flowers of the same plant.

Pollinating agents helps to effect pollination.

Genetically similar to the autogamy.

3. **Xenogamy:**

Transfer of pollen grains from the anther to the stigma of different plant.

It is commonly called as cross-pollination.

It brings genetically different pollen to stigma.

Agents of pollination:

Plant use **abiotic agents (**wind and water) and **biotic agents (**animals) for pollination.

Majority of plants use biotic agents for pollination.

Adaptations for Anemophily (Pollinating agent is wind) **:-**.

- Plants produces enormous amount of pollen.
- Flowers with well exposed stamens.
- Large feathery stigma to trap air-borne pollen grains.
- Most wind pollinated flowers contain single ovule in one ovary and numerous flowers packed into an inflorescence e.g. corn cob.
- Pollen grains are light and non-sticky.

Adaptations for Hydrophily (Pollination by abiotic agent like water**) :-**

This type of pollination is very rare, about 30 genera, mostly monocot.

Vallisneria, Hydrilla* and *Zostera are the common example for Hydrophily.

All aquatic plants doesn't show Hydrophily.

- in ***Vallisneria*** *p*ollen grains released into the surface of water and carried to the stigma by air current.
- In **sea grass** the flowers remains **submerged.**
- Pollen grains are **long, ribbon** like and carried passively inside the water
- Pollen grains are protected from wetting by **mucilaginous covering.**

Adaptations for Pollination by animals

Bees are the dominant biotic agents for pollination.

- Insect pollinating flowers are very large, colorful, fragrant and rich in nectar.
- Small flowers present in cluster to make them conspicuous.
- Flower pollinated by flies and beetles secrete foul odour.
- Nectar and pollen grains are the usual floral rewards for insects.
- In some species, flower provide floral rewards by providing safe places to lay eggs: e.g. ***Amorphophallus.***

A species of **moth** and ***Yucca*** plant cannot complete their life cycle without each other.

The moth deposits its eggs in the locule of the ovary and the flower in turn get pollinated by the moth.

Many insects may consume pollen or nectar without bring about pollination. Such floral visitors are referred as **pollen/nectar robbers.**

Artificial hybridization:

One of the major approaches of crop improvement programme.

Only desired pollen grain used for pollination.

Stigma is protected from contamination (from unwanted pollen grain).

Removal of anthers from the flower bud before the anther dehisces is called **emasculation.**

Emasculated flowers covered by bag generally made up of butter paper, to prevent contamination.

This step is called **bagging.**

Pollen grains collected from desired male parent are dusted after the stigma of emasculated flower attain receptivity. This step is called **artificial pollination.**

After artificial pollination female flower is **rebagged.**

Double fertilization:

After entering one of the synergids, the pollen tube releases two male gametes into the cytoplasm of the synergids.

Syngamy: One of the male gamete fused with egg cell, to form a diploid **zygote.**

Triple fusion: Two polar nuclei of central cell fused to form a diploid **secondary nucleus**.

The second male gamete fused with the secondary nucleus to form a triploid **primary endosperm nucleus (PEN).**

Since **syngamy and triple fusion** take place in the embryo sac, the phenomenon is termed as **double fertilization**.

The central cell after triple fusion becomes **primary endosperm cell** and developed into the **endosperm.**

The zygote developed into an embryo.

Embryo:

Zygote formed and placed at the micropylar end of the embryo sac.

Zygote starts its development only after some amount of endosperm formed.

Embryo development takes place in following stages:

- **Proembryo**
- **Globular embryo**
- **Heart embryo**
- **Matured embryo**

Dicot embryo:

- A typical dicotyledonous **embryo** consists of an **embryonal axis** and two **cotyledons.**
- Embryonal axis above the cotyledon is the **epicotyls.**
- Terminal part of the epicotyls is the **plumule** (gives rise to the shoot).
- Embryonal axis below the cotyledon is the **hypocotyl.**
- The terminal part of the hypocotyl is called the **radicle** gives rise to the root system).
- The root tip is covered by the **root cap.**

Monocot embryo:

- Possesses only one cotyledon
- Single large **cotyledon** is called **Scutellum.**
- Scutellum situated towards one side of the embryonal axis.
- Radicle and the root cap enclosed by a sheath called **Coleorhiza.**
- The portion of the embryonal axis above level of attachment of scutellum is called **Epicotyls.**
- Epicotyl has the shoot apex or plumule enclosed by hollow foliar structure called **Coleoptile.**

Fruit developed from the ovary is called t**rue fruit.**

In apple, strawberry, cashew, the thalamus contributes in the fruit formation and such fruits are called **False fruit**.

Fruit developed without fertilization is called **parthenocarpic fruits.**

Eg :- Pineapple, banana, cucumber, grape, watermelon, orange, grapefruit, pear.

Chapter – 9

STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

Dairy farm management

Dairying is the management of animals for its milk and its products. To increase the yield and improve the quality of milk , following steps should be followed..

1. Selection of breeds with high milk yield and disease resistance.
2. Scientific method of housing.
3. Scientific method of feeding.
4. Follow stringent cleanliness and hygiene while milking.
5. Provide the service of Veterinary Doctor.
6. Provide the facility of mechanized milking.
7. Healthy storage and marketing of milk.
8. Provide regular vaccination.

Bee-keeping :

Bee-keeping or apiculture is the maintenance of hives of honeybees for the production of honey. Honey is a food of high nutritive value. It also produces bee wax which is used for preparation of cosmetics and Polishes.

The most common species of honey bee is ***Apis indica***. The following points are important for successful bee-keeping-

1. Knowledge of the nature and habits of bees
2. Selection of suitable location for keeping the beehives
3. Catching and hiving of swarms
4. Management of beehives during different seasons
5. Handling and collection of honey and of beeswax.
6. Keeping beehives in crop fields during flowering period increases pollination efficiency and improves the yield.

Plant Breeding

Plant Breeding is the purposeful manipulation of plant species in order to create desired plants that are better for cultivation, better yields and disease resistant.

The main steps in plant breeding are-

a) Collection of variability collection and preservation of all the different wild verities, species and relatives of the cultivated species in a given crop is called germplasm collection.

b) Evaluation and selection of parents is the identification of plants with desirable combination of characters. The selected plants are multiplied and used in the process of hybridisation.

c) Cross hybridisation among the selected parents to obtained desired crop crossing the two parents to produce hybrids that genetically combine the desired characters in one plant.

d) Selection and testing of superior recombinants -The selection process is careful scientific evaluation of the progeny. This step yields plants that are superior to both of the parents.

e) Testing, releasing and commercialisation of new cultivars -The newly selected lines are evaluated for their yield and other agronomic traits of quality, disease resistance, etc.

Breeding for improved nutritional qualities

Bio-fortification-Breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats.

The objectives of biofortification is to improve

- **Protein content and quality.**
- **Oil content and quality**
- **Vitamin content**
- **Micronutrient and mineral content**

Biofortified crops

- **Lysine and tryptophan rich maize**
- **Protein rich wheat variety atlas 66**
- **Vitamin A enriched golden rice**
- **Vit A enriched carrot pumkin, spinach**
- **Vit C enriched guard, bathua, mustard**
- **Protein enriched pulses like beans, garden pea, lab lab.**

Single Cell Protein (SCP)

- It is a low cost high quality protein developed from micro organisms like yeast ,spirulina etc.
- These organisms can be grown in waste like molasses, manure or even in sewage water.
- 250Kg cow can produce 200grams protein per day. But 250 grams of ***Methylophilus methylotrophus*** is expected to produce 25 tons of protein.

Advantages of SCP

- Microorganisms like *Spirulina* can be grown in waste water from potato processing plants, straw, molasses, animal manure and sewage.
- Microorganisms can grow faster compared to agriculture and animal farming.

Tissue culture

- It is the process of culturing plant parts in nutrient medium under controlled environment.
- The plant parts used in tissue culture is called explants
- **Totipotency**:-It is the capacity of plant cell to produce a whole plant
- Nutrient medium should contain carbon source [sucrose]macro and micro nutrients, vitamins, amino acids and growth regulators like auxin, cytokinin etc.
- **Micropropagation:-**Production of plantlets through tissue culture is called micropropagation.
- **Somaclones:-** plants developed through tissue culture is identical to parent plant. So they are called somaclones. The variation shown by the individual is called **Somoclonal variation**
  Eg :- Tomato, banana, apple etc.
- Importance of meristem culture:- meristem does not contain viruses ,So by meristem culture disease free plants can be produced. Eg. Banana, sugarcane, potato etc.

Somatic hybridization:

The fusing of the cytoplasms of two different varieties is called somatic hybridisation and these hybrids are called **Somatic hybrids**

Hybridization between tomato and potato is called **Pomato**. But unfortunately this plant is not viable.

Steps:

Isolated protoplast from two different varieties of plants with desirable character are selected and fused to get hybrid protoplast called somatic hybrid.

CHAPTER – 11

BIOTECHNOLOGY: PRINCIPLES AND PROCESSES

Biotechnology is the application of technology in living organisms to produce or modify a product or a process useful to mankind.

Concepts

- **Tools of rDNA technology**
- **Processes of rDNA technology**

Tools of rDNA technology

1. ENZYMES
2. CLONING VECTOR
3. COMPETENT HOST

1. ENZYMES

Types of enzyme	Example	Function
Cleaving Enzymes	Exonucleases	Cut off nucleotide from the terminal end of DNA
	Endonucleases	Make cuts at specific position of single strand within the DNA
	Restriction Endonucleases	Make cut on both strand at specific position of DNA.
Joining Enzyme	DNA Ligases	Used to join (Ligation) cut ends of double stranded DNA.
Lysing Enzyme	Lysozyme	Break the cell wall of bacteria
	Cellulase	Break the cell wall of plant cell
	Chitinase	Break the cell wall of fungus
	Protease	Break down of protein in the cell
	Ribonuclease	Break down the RNA in the cell

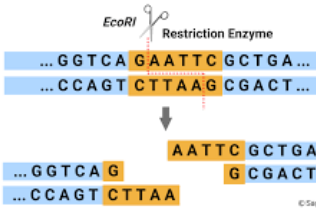
Restriction Endonucleases

- First isolated and characterised restriction endonuclease is ***Hin*d II**
- They cut at specific nucleotide base pair sequence (4-6 bp) of double stranded DNA called **recognition sequence.**
- Recognition sequence of endonuclease enzymes is called **palindromic nucleotide sequence.**
- **palindromic nucleotide sequence** :- Complementary DNA sequences that are same when each strand is read in same direction (5'-3') are called palindromic nucleotide.

Eg:- **5' -------GAATTC-------3'**

3' -------CTTAAG-------5'

ACTIVITY OF *Eco*RI



- Rule for naming of Restriction Endonuclease Enzyme
  - **Ist letter** - First letter in the genus of the bacteria from which the enzyme is derived.
  - **IInd & IIIrd letters** - First two letters from the species of the organism.
  - **IVth letter** - First letter of the strain of bacteria.
  - **Roman number** - Order of isolation.

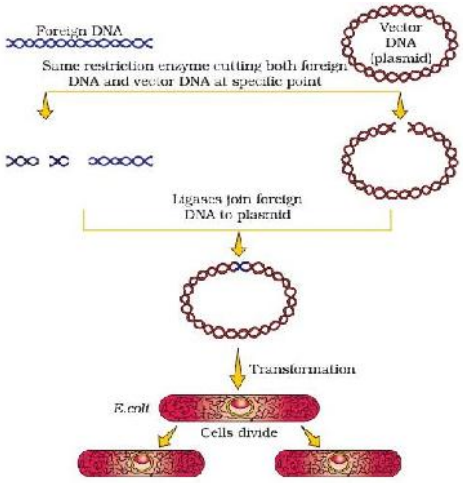
EG:- *Eco*RI - derived from *Escherichia coli* RY 13 and it is Ist to be isolated.

E - *Escherichia* **co - *coli*** **R - RY 13 strain** **I- First order of isolation**

- The overhanging stretch of DNA produced on the palindromic sequence by endonuclease activity is called sticky ends.

Processes of rDNA technology

- Isolation of DNA.
- Fragmentation of DNA using restriction endonucleases.
- Separation & Isolation of desired gene by **Gel Electrophoresis.**
- Amplification of desired gene using **Polymerase Chain Reaction (PCR).**
- Ligation of the DNA fragment into a vector.
- Transferring the recombinant DNA into the host.
- Large scale aseptic culture of transformed cell.
- Downstream processing.



Gel Electrophoresis

- Gel Electrophoresis is used for the isolation and separation of DNA fragment.
- DNA fragments are negatively charged, hence it move towards the positively charged anode through a matrix/medium.
- Most commonly used matrix or medium is **AGAROSE**.
- DNA fragment separate according to its charge and size.
- Separated fragment can be visualised as orange coloured band by exposing to UV light after staining with **Ethydium Bromide**.
- Separated DNA fragments are cut out from the gel and extracted. This step is called **elution**.

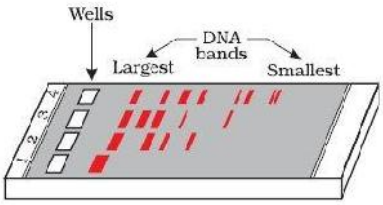


Figure 11.3 A typical agarose gel electrophoresis showing migration of undigested (lane 1) and digested set of DNA fragments (lane 2 to 4)

Polymerase Chain Reaction (PCR)

- In-vitro amplification of desired gene is done by the technique namely PCR.
- Amplification is the process artificial synthesis of multiple copies of desired gene.

Steps in PCR

A. Denaturation

Separation of complimentary strand of DNA at high temperature.

B. Annealing

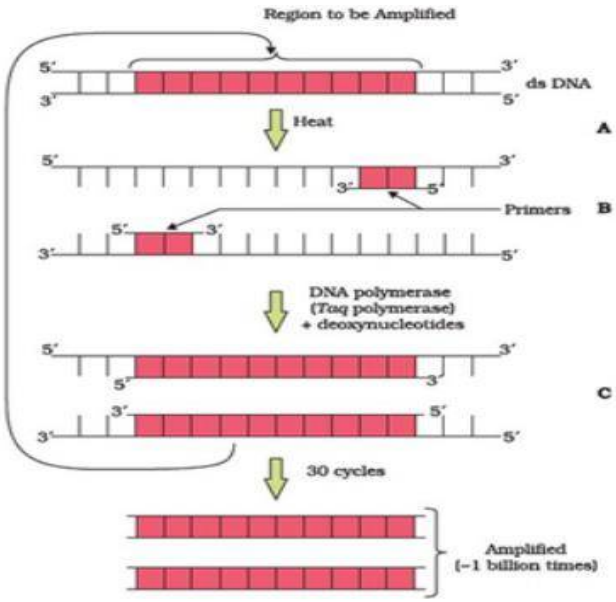
Pairing of primer to the separated DNA strand is called annealing.

C. Extension

Addition of complimentary nucleotides to ends of primer with the help of ***Taq* polymerase** is called extension.

***Taq* Polymerase :** heat stable (thermostable) DNA polymerase enzyme isolated from thermophilic bacterium, ***Thermus aquaticus*.**

Primers : Artificially synthesised oligonucleotide sequence complimentary to the regions of DNA.



Obtaining the Foreign Gene Product

- The ultimate aim of recombinant DNA technology is to produce a desirable product.
- After cloning the gene of interest, the conditions are optimized to produce the product/protein from the gene.
- **Recombinant Protein :-** If any protein encoding gene is expressed in a heterologous host is called recombinant protein.
- Two types of aseptic culture are maintained in order to produce the recombinant product.
    - **Small Scale Culture.**
    - **Continuous Culture System.**

Small Scale Culture.

- Small Scale Culture are employed in laboratory.
- It provide less yield of products compared to continuous culture.
- The product is purified using different extraction techniques.

Continuous Culture System.

- The large scale production of recombinant product can be obtained through **continuous culture.**
- In Continuous Culture, used medium can be drained out from one side while fresh medium is added from other side.
- Cells are always maintained in log/exponential phase of growth.
- It provide high yield of products compared to small scale culture.
- Bioreactors are commonly used for continuous culture.
- Bioreactor provide optimal condition for large scale production of products.

Bioreactors

They are used for large scale production of products by continuous culture method.

It is a large vessel in which raw materials are converted biologically into specific product.

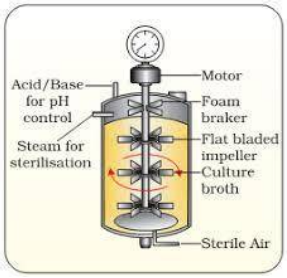
Components of Bioreactor

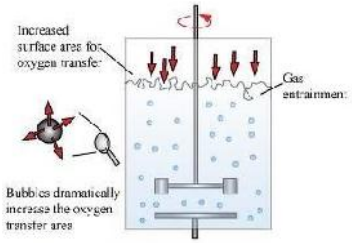
1. Agitator system,
2. Oxygen delivery system
3. Foam control system
4. Temperature and P^H control system
5. Sampling port.

Two type of bioreactors are,

Simple stirred tank bioreactor in which a flat bladed stirrer mixes the oxygen throughout the reactor.

Sparged stirred tank bioreactor in which air is bubbled so that it increases the oxygen transfer area.





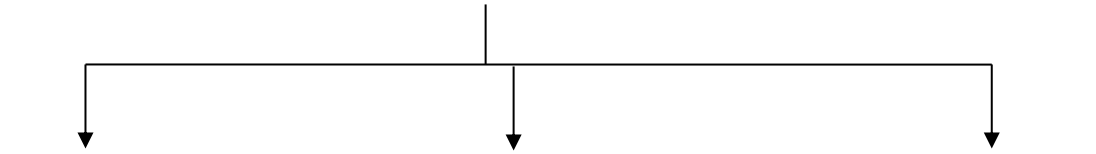
Sparged Stirred Tank Bioreactor

CHAPTER – 12
BIOTECHNOLOGY AND ITS APPLICATIONS

The application of biotechnology for the welfare of man include

1. Therapeutics
2. Diagnostics
3. Genetically modified crops
3. Processed Food
4. Bioremediation
5. Waste management
5. Energy production

Application of Biotechnology



Application in agriculture	Application in Medicine	Transgenic Animals
1. Bt Cotton	1. Genetically Engineered Insulin	
2. Pest Resistant Plant	2. Gene Therapy	
	3. Molecular Diagnosis	

Genetically Modified Organism (GMO)

An organism (bacteria, fungi, plants or animals) whose genetic material is altered is called **G**enetically **M**odified **O**rganism.

Application of Biotechnology in Agriculture

Genetically engineered crop plants revolutionized present day agriculture.

Importance of GM plant in agriculture are,

- Made crops tolerant to abiotic stress (cold, drought, salt & temperature).
- Develop pest resistance.
- Helped to produce reduce post-harvest losses.
- Enhanced nutritional value of food. Eg :- Vitamin 'A' enriched rice
- Increased efficiency of mineral usage by plants.

Bt COTTON

Bt Cotton:- a genetically modified cotton plant with insecticidal protein producing gene from the bacteria ***B**acillus **t**huringiensis*.

Bt represent *Bacillus thuringiensis.*

cry gene :- insecticidal protein of the *Bacillus thuringiensis* is coded by the gene namely cry gene.

cry toxin :- Insecticidal crystalline toxic protein produced by the 'cry gene' of *B. thuringiensis.*

The toxin is also known as Bt toxin.

Activity of Bt Toxin

The Bt toxin is produced by the bacteria as inactive protoxin.

The inactive protoxin is converted into active toxin when ingested by the insect.

This conversion is mediated by the alkaline P^H of insects gut.

Active Bt toxin binds to the gut epithelium and causes cell lysis leading to insect's death.

Inactive Protoxin $\xrightarrow{\text{Alkaline } P^H \text{ of Insects gut}}$ active toxin $\longrightarrow$ gut epithelial cell lysis lead to insect death

Type of cry gene

*cry*IAb gene	- control corn borer.
*cry*IAc gene & *cry*IIAb gene	- control cotton bollworms.

❋ Applications of Biotechnology in Medicine

rDNA technology revolutionized the health care by producing safe and effective drugs.

Recombinant drugs are free from side effects compared to animal derived products.

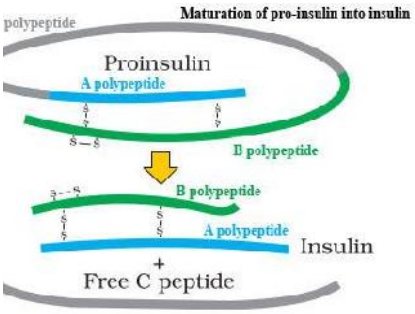
a. Genetically Engineered Insulin (Humulin)

Insulin is a protein hormone secreted by pancreas to control glucose level in blood.

Deficiency of insulin leads to diabetes mellitus.

Insulin Injection is used for the treatment of Diabetic patient.

- Oral administration of insulin is not advised, since insulin is a protein it should be digested by the enzymes of alimentary canal.
- In human body Insulin is produced as inactive Pro-insulin or pro-hormone.
- The pro-insulin contain three polypeptide chain; A chain, B chain and C chain.
- In active insulin C chain is removed and A and B chain are linked by disulphide linkage.



✯ Insulin from an animal sources may cause allergy in some patients.

✯ The major challenge for the production of Human insulin by rDNA technology was assemble the A and B polypeptide.

✵ Human insulin by rDNA technology was first prepared by an **American company Eli Lilly in 1983**.

Steps in the preparation of Human Insulin (rDNA technology)

1. **Eli Lilly Company prepared DNA sequences corresponding to A and B chain of insulin.**
2. **A and B Chain DNA were introduced in plasmid of *E.coli* to produce the A and B chains.**
3. **Chain A and B were produced separately.**
4. **Chain A and B were extracted and combined by creating disulphide bonds**

b. Gene Therapy

Collection of methods that allow correction of a defective gene diagnosed in human is called gene therapy.

ADA deficiency

- **Adenosine DeAaminase** – is an important enzyme involved in the functioning and maintenance of immune system.
- First clinical gene therapy was given in 1990 to a 4 year old girl with ADA deficiency.
- ADA deficiency is due to deletion of gene for adenosine deaminase enzyme.
- ADA deficiency can be treated by 3 methods

  1. Enzyme replacement therapy. 2. Bone marrow transplantation. 3. Gene therapy.

Treatment by enzyme replacement and bone marrow transplantation are not completely curative.

Steps involved in Gene therapy Treatment of ADA deficiency

- Lymphocytes from the patients were isolated.
- In vitro culturing of isolated lymphocytes.
- Using **retroviral vector** cDNA (complimentary DNA) of functional ADA gene was introduced into the lymphocyte.
- Lymphocyte with functional ADA gene was returned to patient's blood.
- Periodic infusions of genetically engineered lymphocyte into patient since the cells are mortal.

ADA deficiency can be completely cured if ADA producing gene isolated from bone marrow cells is introduced into cells at early embryonic stage.

CHAPTER – 13
ORGANISMS AND POPULATIONS

Ecology is basically concerned with four levels of biological organization-organisms, populations, communities and biomes.

Major Abiotic Factors:- Major Abiotic Factors are Temperature, Water, Light, and Soil, varies with different habitat of organisms.

Temperature

Temperature affects the kinetics of enzymes activity and other physiological functions.

Eurythermal: Organisms which can tolerate wide range of temperatures are called eurythermal organisms. eg. Toad, Wall lizard.

Stenothermal: Some organism which can tolerate narrow range of temperatures are called stenothermal organisms. Eg. Snails, snakes, palms.etc

Water

In aquatic habitat quality of water such as chemical composition, p^H and salinity are important .

Euryhaline : Organisms which can tolerate wide range of salinity are called euryhaline.

Stenohaline : Some organisms are tolerate of a wide range of salinities (euryhaline) but others are restricted to a narrow range (stenohaline).

Adaptation

Adaptation is the morphological, physiological, behavioral character that enables the organism to survive and reproduce in its habitat. Many adaptations are genetically fixed.

1. **Adaption of desert animals** - In the absence of water, the **kangaroo rat** is meeting its water requirements through its internal fat oxidation. It concentrates its urine so that minimal volume of water is used to remove excretory products.

2. Desert plants have a thick cuticle, less leaves, flattened stem etc. Their stomata arranged in deep pits (Sunken stomata) to minimize water loss through transpiration. They have a special photosynthetic pathway (CAM)

3. Adaptation of animal in cold climate: Allen's Rule: mammals from colder climates generally have shorter ears and limbs to minimize heat loss. Seals of polar aquatic seas have a thick layer of fat called **blubber** below their skin that acts as insulator and reduces loss of body heat.

4. Adaptation in high altitude: A person move to high altitude (>3,500 meter), develop **altitude sickness.** Symptoms developed are nausea, fatigue and heart palpitations. This is due to low atmospheric pressure of high altitudes; the body does not get enough oxygen. The body compensates low oxygen availability by increasing red blood cell production. The body compensates decreasing binding capacity of hemoglobin with oxygen by increasing rate of breathing.

POPULATIONS :- is a group of individuals of same species sharing similar resources.

population attributes - birth rates and death rates, sex ratio, Population size, age distribution.

1. **Birth and death rates** In a population birth and death rates refer to per capita births and deaths, respectively.

2. Sex ratio. A population have characteristic ratio of male and females. If the age distribution is plotted for the population, the resulting structure is called an age pyramid The shape of the pyramids reflects the growth status of the population - (a) whether it is growing, (b) stable or (c) declining.

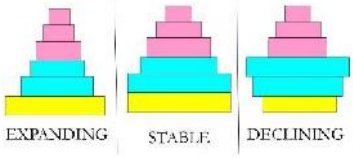
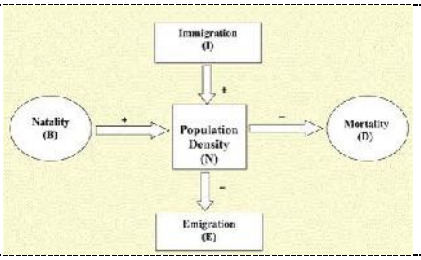
3. **Population size**- Population size or **population density** is the size of a population for any species. It is not a static. It keeps changing in time. The density of a population in a given habitat during a given period fluctuates due to changes in four basic processes, natality and immigration contribute an increase in population density and mortality and emigration decrease the population size.

Natality refers to the number of births, **Mortality** is the number of deaths ,**Immigration** is the number of individuals of the same species that come into the habitat from other population., **Emigration** is the number of individuals of the population who left the habitat .

So, if N is the population density at time t, then its density at time t **+** 1 is

$$N_{t+1} = N_t + [(B + I) – (D + E)]$$

Population density will increase if the number of births plus the number of immigrants (B + I) is more than the number of deaths plus the number of emigrants (D + E).

AGE PYRAMIDS	FACTORS AFFECTING POPULATION DENSITY
	

Growth Models

Exponential or geometric growth :-The population grows in an exponential or geometric growth pattern of a population results in a J-shaped curve . Any species growing exponentially **under unlimited resource** conditions can reach enormous population densities in a short time.

Growth rate of an exponential growth is $dN/dt = (b-d)N$

Let (b-d) = r , then the equation becomes, $dN/dt = rN$ / $N_t = N_o e^{rt}$

r = intrinsic rate of natural increase.

2.**Logistic growth (Verhulst-Pearl Logistic growth or Sigmoid Growth)**

In nature, a given habitat has enough resources to support a maximum possible number, beyond which no further growth is possible. Let us call this limit as nature's **carrying capacity (K)** for that species in that habitat. A population growing in a habitat **with limited resources** show initially a lag phase, followed by phases of acceleration and deceleration and finally an asymptote, when the population density reaches the carrying capacity.

Growth rate of an exponential growth is

$$dN/dt = rN\left[\frac{K-N}{K}\right]$$

N = Population density at time t, r = intrinsic rate of natural increase, K = Carrying capacity.

Population Interaction

Species A	Species B	Name of Interaction	Feature
+	+	MUTUALISM	Both species gets benefited
–	–	COMPETITION	Both species are harmed
+	–	PREDATION	One species get benefited (Predator) other harmed (Prey).
+	–	PARASITISM	One species get benefited (Parasite) other harmed (Host).
+	0	COMMENSALISM	One species get benefited other neither benefited nor harmed.
–	0	AMMENSALISM	One species get harmed other neither benefited nor harmed.

Parasitism:

Many parasites have to be host-specific in such a way that both host and parasite tend to co evolve.

Special adaptations of parasites-

- The loss of unnecessary sense organs, presence of adhesive organs or suckers to cling on to the host, Loss of digestive system and high reproductive capacity.
- The life cycles of parasites are often complex, involving one or two intermediate hosts or vectors to facilitate parasitisation of its primary host.

1. **Ectoparasites**- Parasites that feed on the external surface of the host organism are called ectoparasites. Eg- lice on humans and ticks on dogs. Many marine fish are infested with ectoparasitic copepods. Cuscuta , a parasitic plant that lost its chlorophyll .
2. **Endoparasites** -are those that live inside the host body at different sites (liver, kidney, lungs, red blood cells, etc.). Life cycle is more complex. Morphological and anatomical features are greatly simplified. Highly developed reproductive system.
3. **Brood parasitism** - In which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them.

Commensalism: One species benefits and the other is neither harmed nor benefited.

Eg :- 1. An orchid growing as an epiphyte on a mango tree.
2. barnacles growing on the back of a whale.
3. The cattle-egret and grazing cattle in close association.
4. The interaction between sea anemone and the clown fish.

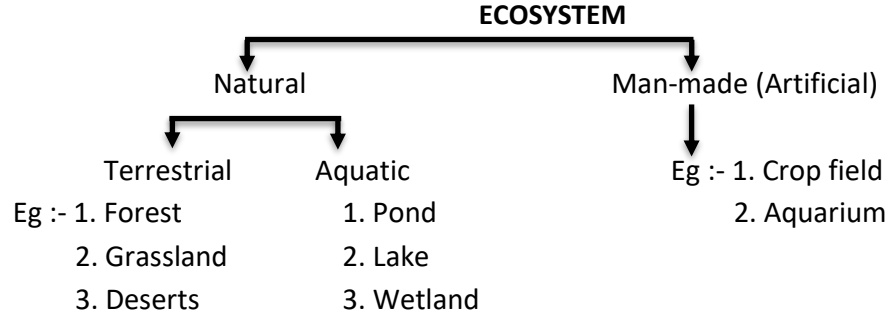
Mutualism: (++) Eg.1. Lichens- It is interaction between a fungus and photosynthesizing algae or cyanobacteria.2. Mycorrhizae are associations between fungi and the roots of higher plants. 3. Plant-animal relationships -. Plants need the help of animals for pollinating their flowers and dispersing their seeds. Plants offer rewards or fees in the form of pollen and nectar and juicy and nutritious fruits .

Co-evolution- the evolutions of the flower and its pollinator species are tightly linked with one another. A fig species can be pollinated only by its 'partner' wasp species. The female wasp uses the fruit not only as an ovipositor (egg-laying) site but uses the developing seeds within the fruit for nourishing its larvae. In tern the wasp pollinates the fig inflorescence. Orchids show diversity of floral patterns many of which have evolved to attract the right pollinator insect.

Sexual deceit:- orchid *Ophrys* employs 'sexual deceit'. Petal of the flower resembles the female bee. The male bee attracted to what it perceives as a female, pseudo copulates with another flower.

CHAPTER – 14
ECOSYSTEM

Ecosystem is a functional unit of nature, where living and nonliving components interact together.
Ecosystem have structural and functional components.
Types of Ecosystems



Components of the ecosystem

(i) Productivity; (ii) Decomposition; (iii) Energy flow; and (iv) Nutrient cycling.

1. PRODUCTIVITY :-

Primary productivity :- The rate of biomass or organic matter produced per unit area over a time period by plants during photosynthesis is called primary productivity. It is expressed in weight (gm/m^{-2}) or energy ($kcal\ m^{-2}$).

Primary productivity divided into

Gross primary productivity – The rate of total production of organic matter during photosynthesis by plants.

Net primary productivity - Gross primary productivity minus respiration losses (R) is the net primary productivity.

Secondary productivity - rate of formation of new organic matter by consumers.

Annual net primary productivity of whole biosphere is about 170 billion tons (dry weight) of organic matter and primary productivity of the oceans are only 55 billion tons.

GPP – R = NPP

Factors affecting primary productivity

1. The plant species inhabiting an area. 2. Environmental factors. 3. Availability of nutrients.
4. Photosynthetic capacity of plants.

2. DECOMPOSITION :-

It is the breakdown of complex organic matter by decomposers into inorganic substances like CO_2, water and nutrients. It is largely an oxygen-requiring process.

The important steps of decomposition are **fragmentation, leaching, catabolism, Humification and mineralization.**

1. Fragmentation : Break down of detritus into smaller particles by detritivores (earthworm).

2. Leaching: Water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.

3. Catabolism : Bacterial and fungal enzymes degrade detritus into simple inorganic substances.

4. Humification : Accumulation of dark colored amorphous substances called humus is formed in this stage.

Importance of humus: It is highly resistance to microbial action. It undergo decomposition at an extremely slow rate. Being colloidal in nature, it serves as reservoir for nutrients.

5. Mineralization : The humus is further degraded by some microbes and release of inorganic nutrients.

Factors affecting decomposition – 1. Oxygen-requiring process. 2. Controlled by chemical composition of detritus 3. climatic factors.

Decomposition rate is slower if rich in lignin and chitin, and quicker, if rich in nitrogen and water-soluble substances like sugars. Temperature and soil moisture are most important climatic factor that regulate decomposition Warm and moist environment favor decomposition.

3. **ENERGY FLOW**

Sun is the only source of energy for all ecosystems on Earth. Less than 50% of incident solar radiation is **photo synthetically active radiations (PAR)**. Plants capture only 2-10 per cent of the PAR. Energy transfer is not absolute, and spontaneous, unless energy is degraded it cannot be transfer. When energy transferred from one trophic level to another, lot of energy lost in the form of heat to the environment.

Law of 10 percentage :- Only 10% of energy is transferred from one trophic level to other.

Flows of solar energy through different organisms in an ecosystem- Unidirectional flow of energy from the sun to producers and then to consumers.

Food chains

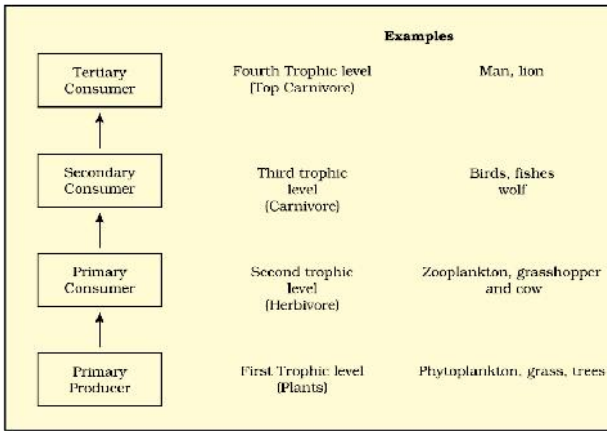
The transfer of energy through a series of organisms linked by the process of eating and being eaten is known as the food chain.

Types of food chain

1. **Gracing food chain (GFC)** —Starts with producers (green plants) Eg. Grass→Goat→Man
2. **Detritus food chain (DFC)** —Starts with detritus Eg. Detritus→Detritivores

Consumers / Heterotrophs

Starting from the plants, (producers) food chains are formed in order to transfer energy. All animals depend on plants (directly or indirectly) for their food needs. They are hence called consumers and are heterotrophs.



Primary consumers

If they feed on the producers, the plants, they are called primary consumers.

Secondary consumers

If the animals eat herbivores are called secondary consumers.

Trophic level

Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as their **trophic level.**

Producers belong to the **first trophic level**, **herbivores** to the **second trophic level** and **carnivores** to the **third trophic level.** The amount of energy decreases at successive trophic levels.

Food Web

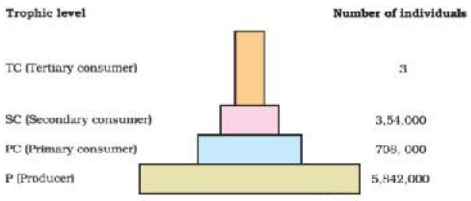
Several food chains are interconnected to form a network called food web.

Ecological Pyramid

It is the graphical representation of ecological parameters like number of organisms, biomass and energy at different trophic levels in a food chain.

The base of the pyramid represents producers/first trophic level where as the top of the pyramid represents top level consumers.

An ecological pyramid may be Upright or Inverted.

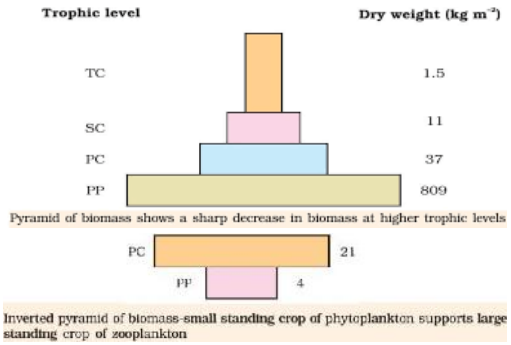


Pyramid of Number :-

Ecological pyramid based on the number of organism in each trophic level.

Pyramid of number is upright for grass land ecosystem but inverted for single tree ecosystem.

Pyramid of Biomass:-



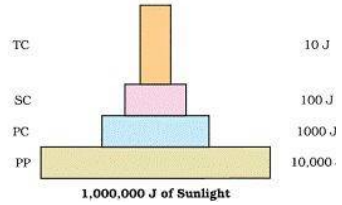
Ecological pyramid based on the biomass of organism in each trophic level.

Pyramid of biomass is upright for grass land ecosystem but inverted for sea ecosystem.

Pyramid of Energy :-

Ecological pyramid based on the amount of energy in each trophic level.

It is always upright. Because, when energy flows from one trophic level to the next level some energy is lost as heat at each step. It always follow law of 10%.



4. NUTRIENT CYCLING

The movement of nutrient elements through the various components of an ecosystem is called nutrient cycling (Biogeochemical Cycle).

The reservoir for gaseous type of nutrient cycle (nitrogen, carbon) exists in the atmosphere. The reservoir for sedimentary cycle (Sulphur, Phosphorus) is earth's crust.

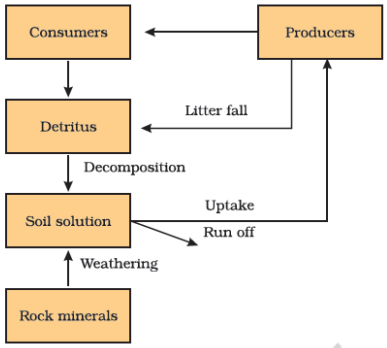
The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc., present in the soil at any given time, is referred to as the standing state.

Nutrient cycles are of two types:

(a) Gaseous Cycle :- Eg :- Nitrogen Cycle, Carbon Cycle.

(b) Sedimentary Cycle :- Eg :- Sulphur Cycle, Phosphorus Cycle.

Phosphorus Cycle



The natural reservoir of phosphorus is rock, which contains phosphorus in the form of phosphates.

When rocks are weathered, phosphates dissolve in soil solution and are absorbed by plants.

Herbivores and other animals obtain this element from plants.

The waste products and the dead organisms are decomposed by phosphate-solubilising bacteria releasing phosphorus.

CHAPTER – 16
ENVIRONMENTAL ISSUES

WATER POLLUTION

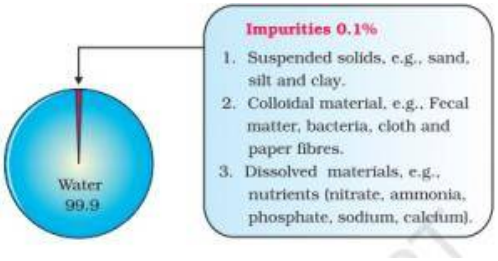
- Any undesirable change in the physical, chemical and biological composition of water that adversely affects the living organisms is called water pollution.
- Government of India has passed the **Water (Prevention and Control of Pollution) Act, 1974** to protect water resources and to maintain the cleanliness of the water bodies.

Major Water Pollutants and their source

1. Domestic Sewages.
2. Industrial Effluents.
3. Agricultural wastes and leach outs.
4. Heated waste waters from electricity generating units

Water pollutants mainly contain **solid wastes**, **dissolved salts** (nitrates, phosphates) and **toxic metal ions** and **organic compounds**.

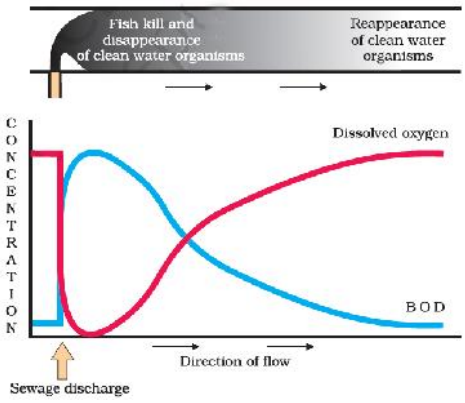
Domestic sewage primarily contains **biodegradable organic matter**, which readily decomposes by bacteria and other micro-organisms.



BIOCHEMICAL OXYGEN DEMAND (BOD)

- It is the **measurement of amount of biodegradable organic matter in sewage water**.
- Biodegradation of organic matter by micro- organisms results in the sharp decline (decrease) in dissolved oxygen in the water. This causes **death of fish and other aquatic creatures**.

✯While increasing the organic waste discharge in the water body, **demand for the oxygen** (BOD) also increases, but dissolved oxygen decreases and vice- versa.



BIOMAGNIFICATION

- Waste water from industries like petroleum, paper manufacturing, metal extraction, chemical manufacturing, etc. contain toxic substances. (e.g., - Heavy metals like Mercury, Copper, Cadmium, Lead, etc.)
- Some of these toxic substances can enter the aquatic food chain and causes Biomagnification.
- **Phenomenon of increase in concentration of the toxicant at successive trophic levels** is called **Biomagnification** or **Biological magnification** or **Bio-amplification.**
- These toxic substances once accumulated cannot be metabolized or excreted.
- Biomagnification is well known for **Mercury** and **DDT**.

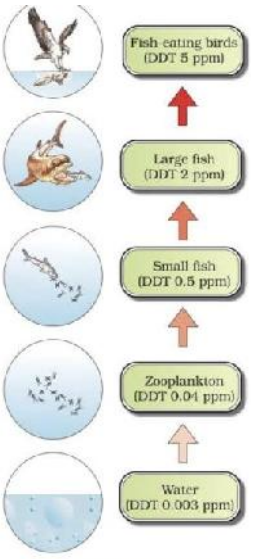


Figure Biomagnification of DDT in an aquatic food chain

Effect of high concentration of DDT in birds

- Disturbs calcium metabolism.
- Thinning of egg shells and premature breaking.
- Causes decline in bird population.

ALGAL BLOOM

- Presence of large amount of nutrients in water causes excessive growth of planktonic (free – floating) algae called algal bloom.

Effects of algal bloom

- Algal bloom imparts a distinct color to the water bodies.
- Algal bloom causes deterioration of the water quality and causes fish mortality.
- Some bloom- forming algae are toxic to human beings and animals.

EUTROPHICATION

- Eutrophication is the **natural aging of a lake** by nutrient enrichment.
- Eutrophication finally **leads to the conversion of water body in to land.**
- Pollutants from man's activities like effluents from the industries and homes accelerate the aging process, and this phenomenon is called **Cultural Eutrophication** or **Accelerated Eutrophication.**
- *Eutrophication is mostly caused by* **sewage, industrial wastes** and **agricultural wastes.**
- The major contaminants for eutrophication are **nitrates** and **phosphates** which act as **plant nutrients**.

Effects of Eutrophication:

- causes unsightly scum and unpleasant odors.
- robbing the dissolved oxygen from water.
- causes death of fishes and aquatic animals.
- decomposition of fishes reduces the dissolved oxygen.
- decrease in the biodiversity of water bodies.

Water hyacinth *(Eichhornia crassipes), world's most problematic aquatic weed* *commonly known as* ***'Terror of Bengal'***

- they grow abundantly in eutrophic water bodies.
- causes imbalance in the ecosystem dynamics of the water body.

Effects of thermal (heated) waste waters electricity generating units (thermal power plants)

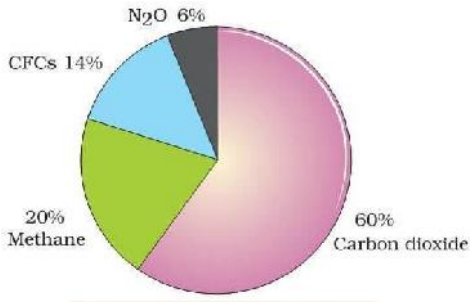
- Thermal waste water eliminates or reduces the number of organisms sensitive to high temperature.
- Enhances the growth of plants and fishes in extremely cold areas.
- Leads to the damage of indigenous flora and fauna.

GREENHOUSE EFFECT AND GLOBAL WARMING

- Greenhouse Effect is a naturally occurring phenomenon which is responsible for **heating of earth's surface** and **atmosphere.**
- Greenhouse effect is just similar to the rise in temperature inside the glass house and a car that parked in the sunlight.

Mechanism of formation of greenhouse effect

- Cloud and gases reflect about one-fourth of the incoming solar radiation and absorb some of it.
- Almost half of incoming solar radiation falls on Earth's surface heating it, but a small portion is reflected back.
- Earth's surface re-emits heat in the form of Infra- red radiation.



Relative contribution of various greenhouse gases to total global warming

- But greenhouse gases absorb a major portion of this heat. Thus these infra- red radiation cannot escape in to the space.
- Major greenhouse gases that responsible for greenhouse effect are **Carbon dioxide, methane, CFCs** and **Nitrous oxides (N_2O)**.
- The molecules of the greenhouse gases radiate heat energy and increases heat on the Earth's surface.
- **The mean annual temperature of earth surface is about 15^oC. But in the absence of greenhouse gases, the average temperature would drop to $^-$18^oC.**

EFFECTS OF GREEN HOUSE EFFECT/ GLOBAL WARMING

1. Rise in temperature **leads to deleterious changes in the environment** and **resulting in odd climatic changes** (e.g., - **El Nino effect**, Cyclones, etc.
2. Increased melting of polar ice caps, Himalayan snow caps, etc.
3. Rise in sea level which may leads to submerging of coastal areas and Islands.

CONTROL OF GREEN HOUSE EFFECT/ GLOBAL WARMING

- Reduce the use of fossil fuels.
- Improve the efficiency of energy usage.
- Reduce deforestation.
- Slowing down the growth of Human Population
- Planting more trees (Reforestation and Afforestation)
- Taking International initiatives to reduce the emission of greenhouse gases.

OZONE DEPLETION IN THE STRATOSPHERE

- **Ozone** found in the **upper part of the atmosphere** (**stratosphere)** is known as **good ozone**. This Stratospheric ozone **acts as a shield absorbing UV radiations** from the sun. It **protects the earth from the harmful UV rays**.
- **Ozone** formed in the **lower part of theatmosphere** (**troposphere**) is referred as **Bad Ozone** that harms plants and animals.
- **UV radiations can break the chemical bonds in DNA, Proteins**, etc.
- The **thickness of the ozone** is **measured** in **Dobson Units** (**DU**).
- **Ozone is formed by the action of UV rays on molecular oxygen** and **also degraded in to molecular oxygen** in the stratosphere.
- The balance of formation and degradation of ozone has been disrupted due to the enhancement of ozone depletion by **chlorofluorocarbon (CFCs).**
- **CFCs from refrigerants** discharged in the lower part of the atmosphere move upward and reached stratosphere.
- In stratosphere, **UV radiations** act on CFCs and **releases Cl atoms**.
- Chlorine atoms degrade ozone releasing molecular oxygen. Here **Cl acts as catalyst** for the degradation of Ozone. Cl atoms are not consumed in the reaction.
- This **degradation of ozone in the stratosphere** is known as **ozone depletion**.
- A large area of **thinned ozone layer** due to ozone depletion **over the Antarctic region** is called **ozone hole.**

MONTREAL PROTOCOL (1987)

- It is an International treaty **signed in 1987 at Montreal (Canada) to control the emission of Ozone depleting gases**.
- Montreal Protocol was **effective from 1989**.

Harmful effects of UV - B radiations:

- It damages the DNA and causes mutation.
- It causes aging of skin.
- It damages skin cells and causes skin cancers.
- Cornea absorbs UV radiations and causes **inflammations of cornea** called **Snow Blindness,** cataract, etc.
- Exposure of UV rays permanently damage the cornea.

DEFORESTATION

- Deforestation is the **conversion of forested areas to non – forested areas**.
- 40% forest has been lost in the tropics but 1% loss in the temperate regions.
- At the beginning of the 20^{th} century, India has a forest cover about 30%. But at the end of 20^{th} century it shrunk to 19.4%.
- **National Forest Policy (1988) of India** has recommended 33% forest cover for the plains and 67% for the hills.

Reasons for Deforestation

1. Conversion of forest to agricultural land *to feed the growing population*.
2. Demand of forest products like Timber, Fire wood, etc.
3. Hydroelectric projects with in dense forests.
4. Mining operations in forests.
5. Industrialization, road, rail and airport construction.
6. **Slash and burn agriculture (Jhum cultivation)** in the North- Eastern states of India also contributed to deforestation.
   - farmers cut down the trees of the selected forest areas and burn the plant remains.
   - ash is used as fertilizer.
   - land is then used for the cultivation/farming or cattle grazing.
   - After cultivation, the land is left for several years for the recovery of forests.
   - farmers then move on to other areas and repeat this process.
   - Due to increasing population and repeated cultivation, forest recovery is done away with, resulting in deforestation.

Effects of Deforestation/ consequences of Deforestation

1. Enhanced carbon dioxide concentration in the atmosphere.
2. Loss of Biodiversity.
3. Disturbs hydrologic (water) Cycle.
4. Soil erosion.
5. Desertification

REFORESTATION:

- Reforestation is the process of restoring a forest that once existed but it was removed at some point of time in the past.
- Reforestation can be speed up by planting trees.