Unit-3 : Biology and Human Welfare

Chapter-1 : Human Health and Diseases

TOPIC-1

Health, Common Diseases in Human and Immunity

Revision Notes

- Health is a state of complete physical, mental and social well-being.
- Health simply does not means disease free condition or physical fit-ness.
- Health is affected by:
  (a) Genetic disorders – the defect which child inherits from its parents.
  (b) Infections from microbes or other organisms.
  (c) Life style – includes food and water we take, exercise and rest.
- When people are healthy, they are more efficient at work. This increase productivity and brings prosperity. It also increases longevity of people and reduces infant and maternal mortality.
- **Good health can be maintained by:**
  (a) Balanced diet.
  (b) Personal hygiene.
  (c) Regular exercise.
  (d) Awareness about the disease and their effect.
  (e) Immunization against the infectious disease.
  (f) Proper disposal of wastes.
  (g) Control of vectors.
  (h) Maintenance of hygienic food and water.

Types of Diseases

- Diseases can be of two types namely, communicable and non-communicable.
- The diseases which are easily transmitted from infected person to healthy persons are called communicable (infectious) disease and diseases which cannot be transmitted from one person to other are called non-communicable (non- infectious) disease.
- The disease causing micro-organisms like bacteria, virus, fungus, protozoa, helminths are called pathogen.
- The pathogen can enter the body by various means and multiply and interfere with normal vital activities resulting in morphological and functional damage.

Common Communicable Diseases in Man

Bacterial Diseases

Pneumonia

Pathogen: *Streptococcus pneumoniae* & *Haemophilus influenzae.*

Mode of Transmission: Inhaling the droplets/aerosols released by an infected person, sharing glasses and utensils with an infected person.

Symptoms:

(a) Infects alveoli of the lungs where by the alveoli get filled with fluid leading to respiratory problems.

(b) Fever, chills, cough, headache.

(c) **Severe cases:** Lips and finger nails turn grey to bluish colour.

Other Bacterial Diseases

Disease	Pathogen	Transmission
Dysentery	*Shigella dysenteriae*	Contact, Contaminated food and water
Plague	*Pasteurella pestis*	Rat fleas
Diphtheria	*Corynebacterium diphtheriae*	Contaminated food, Direct contact
Cholera	*Vibrio cholerae*	Food & water contaminated with faeces
Tuberculosis	*Mycobacterium tuberculosis*	Droplets from patient/carrier
Tetanus	*Clostridium tetani*	Contamination of wound by bacteria
Whooping cough	*Bordetella pertussis*	Contact, Droplets
Leprosy	*Mycobacterium leprae*	Direct contact
Anthrax	*Bacillus anthracis*	Contact with cattle
Weil's disease	*Leptospira icterohemorrhagiae*	Contact with rodents, dogs etc.

Viral Diseases

Common cold

Pathogen: *Rhino viruses*

Mode of Transmission: Inhaling droplets resulting from cough or sneezes, through contaminated objects.

Symptoms:

(a) Infects nose & respiratory passage.

(b) Nasal congestion and discharge, sore throat, hoarseness, cough, headache, tiredness etc.

(c) Last for 3-7 days.

Other Viral Diseases

Disease	Pathogen	Transmission
Rabies	*Rabies virus*	Rabid dogs
Dengue	*Dengue virus*	*Aedes* mosquito
Influenza	*Influenza virus*	Coughing & sneezing
Measles	*Rubeola virus*	Droplets
German measles	*Rubella virus*	Close contact
Mumps	*Mumps virus*	Air borne droplets
Chicken pox	*Varicella zoster*	Air borne droplets
Small pox	*Variola virus*	Direct contact
Polio	*Polio virus*	Faeces & Air
Chikungunya	*Chik virus*	*Aedes* mosquito
Avian flu	*H5N1 virus*	Contact with infected poultry, air borne spread
H1N1 (Swine flu)	*H1N1 virus*	Contact with pigs, cough & sneeze of infected person.

Protozoan Diseases

Malaria

Pathogen: *Plasmodium sp. (P. vivax, P. malariae, and P. falciparum).*

Mode of Transmission: Bite of infected female *Anopheles* mosquito.

Symptoms: Haemozoin causes chill and high fever recurring every 3-4 days.

Life Cycle of Plasmodium:

- Plasmodium enters the human body as sporozoites (infectious form) through the bite of infected female *Anopheles* mosquito.

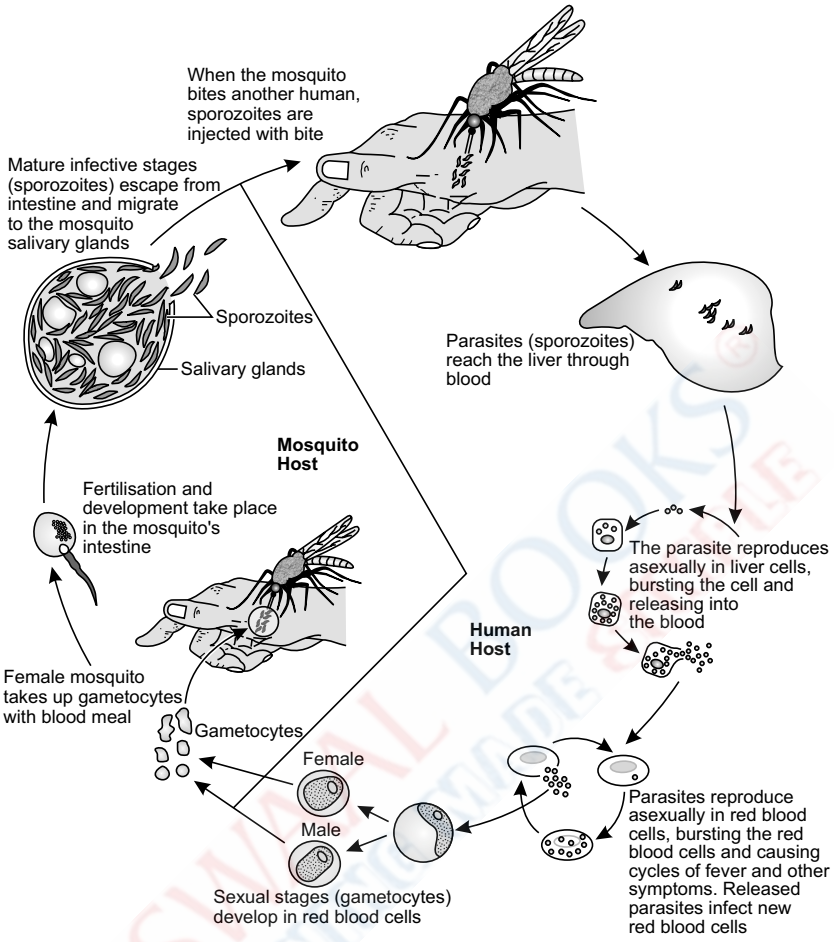

Fig. 1.1: Stages in the life cycle of *Plasmodium*

- The parasites initially multiply within the liver cells and then attack the red blood cells (RBCs) resulting in their rupture.
- The rupture of RBCs is associated with release of a toxic substance, haemozoin, which is responsible for the chill and high fever recurring every three to four days.
- When a female *Anopheles* mosquito bites an infected person, these parasites enter the mosquito's body and undergo further development.
- The parasites multiply within them to form sporozoites that are stored in their salivary glands.
- When these mosquitoes bite a human, the sporozoites are introduced into his/her body.
- The malarial parasite requires two hosts to complete its life cycle namely, human and mosquito.
- The female *Anopheles* mosquito is the vector (transmitting agent).

Fungal Diseases

Ring worms

Pathogens: *Microsporum*, *Trichophyton* and *Epidermophyton*.

Mode of Transmission:

(a) From soil or by using towels, clothes, comb of infected individuals etc.

(b) Heat and moisture help fungi to grow.

Symptoms:

(a) Appearance of dry, scaly lesions on various body parts such as skin, nails and scalp.

(b) Intense itching.

(c) They are seen growing in between toes, in the groin, etc.

Prevention and Control of Diseases

1. **Personal hygiene**
   (a) Keep the body clean.
   (b) Use clean drinking water, food etc.
2. **Public hygiene**
   (a) Proper disposal of wastes and excreta.
   (b) Periodic cleaning and disinfection of water reservoirs, pools, cesspools and tanks.
   (c) Avoid contact with infected persons or their belongings (to control air-borne diseases).
   (d) Observing standard practices of hygiene in public catering.
   (e) Control and eliminate the vectors (*e.g.*, mosquitoes) and their breeding places.
3. **Methods to Control Breeding Places**
   (a) Avoid stagnation of water.
   (b) Regular cleaning of household coolers.
   (c) Repair any leaky pipes.
   (d) Introduce larvivorous fishes like *Gambusia* in ponds.
   (e) Spraying insecticides in ditches, drainage and swamps.
   (f) Doors and windows should be provided with wire mesh to prevent entry of mosquitoes.
   (g) These precautions can avoid breeding of vector's which cause diseases like Malaria, Filariasis, Dengue and Chikungunya.

Immunity

- It is the ability of the immune system to fight against the disease-causing organisms.
- It is of two types namely :

Innate Immunity and Acquired Immunity

(i) Innate immunity

- It is the non-specific defense present at the time of birth.
- It provides different types of barriers to the entry of foreign agents into our body.
- It consists of four types of barriers.

(a) Physical barriers: It includes:

- Skin (Prevent entry of foreign bodies).
- Mucous coating of epithelium lining the respiratory, gastro-intestinal and urino-genital tracts to trap microbes entering our body.

(b) Physiological barriers: It includes acid in the stomach, saliva in the mouth, tears from eyes–all prevent microbial growth.

(c) Cellular barriers: It includes leucocytes (WBC) such as neutrophils or Polymorpho-nuclear leucocytes (PMNL-neutrophils), monocytes and natural killer lymphocytes, macrophages etc.

(d) Cytokine barriers: It includes virus infected cells, which secrete proteins called interferons that protect non-infected cells from further viral infection.

(ii) Acquired immunity

- It is pathogen specific immunity.
- It is characterized by memory, i.e., during first encounter of a pathogen, our body produces primary response in low intensity. Second encounter with the same pathogen produces a secondary (anamnestic) response in high intensity.
- The primary and secondary immune responses are carried out with two special types of lymphocytes namely, B-lymphocytes and T-lymphocytes.

(a) B-lymphocytes (B-cells)

- It produces proteins in response to pathogens into our blood to fight with them.
- These proteins are called antibodies.

(b) T-lymphocytes (T-cells)

- It helps B-cells to produce antibodies.
- Each antibody molecule has four peptide chains namely,

(a) Two small chains called light chains
(b) Two longer chains called heavy chains

- Hence, an antibody is represented as $H_2 L_2$
- Types of antibodies produced in our body: IgG, IgA, IgM, IgE and IgD.

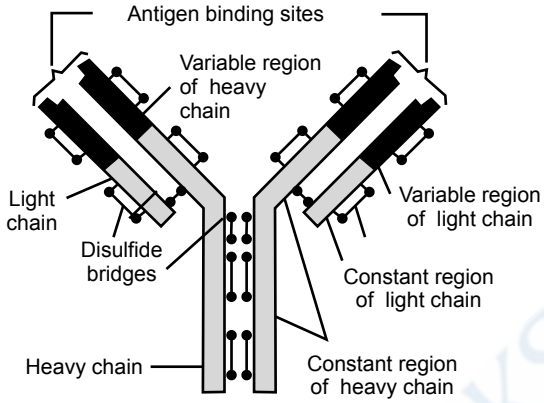

Fig. 1.2: Structure of an Antibody Molecule

Acquired Immune Response

- These are of two types namely: Antibody mediated response and cell mediated response.
  (a) **Humoral or Antibody mediated response/Antibody mediated immunity (AMI):** Because these antibodies are found in the blood, the response is also called as humoral immune response.
  (b) **Cell-mediated response/cell-mediated immunity (CMI):**
    - T-lymphocytes (T-cells) mediate CMI.
    - CMI is responsible for graft rejection.
    - The body is able to differentiate between 'self' and 'non-self'.
    - Tissue matching & blood group matching are essential before undertaking any graft/transplant. After this, the patient has to take immune-suppressants all his life.

Types of Immunity

There are two types of immunity namely: **Active immunity and passive immunity**.

(a) Active Immunity

- When a host is exposed to antigens, which may be in the form of living or dead microbes or other proteins, antibodies are produced in the host body. This type of immunity is called active immunity.
- Active immunity is slow and takes time to give its full effective response.
- Injecting the microbes deliberately during immunisation or infectious organisms gaining access into body during natural infection induce active immunity.

(b) Passive Immunity

- When ready-made antibodies are directly given to protect the body against foreign agents, it is called passive immunity.
- The yellowish fluid colostrum secreted by mother during the initial days of lactation has abundant antibodies (IgA) to protect the infant.
- The foetus also receives some antibodies from their mother, through the placenta during pregnancy.

Vaccination and Immunization

- Immunization is based on the memory of the immune system.
- There are two types namely: active immunization and passive immunization.

(a) Active Immunization

- A preparation of vaccine (antigenic proteins of pathogen or inactivated pathogen) is introduced into body.
- The antibodies produced in the body against the antigens neutralize the pathogenic agents during actual infection.
- The vaccines also generate memory B and T-cells that recognize the pathogen quickly.
  e.g., Polio vaccine, Hepatitis B vaccine, DPT vaccine etc.
- Vaccines are produced using DNA recombinant technology (e.g., Hepatitis B vaccine produced from Yeast).

(b) Passive Immunization

- It is the direct injection of pre-formed antibodies or antitoxin. It is required for quick immune response.
  e.g., Immunization against Tetanus, snake venom etc.

Allergy

- It is the exaggerated response of the immune system to certain antigens present in the environment.
- The substances causing allergy are called allergens.
  e.g., mites in dust, pollens, animal dander, fur etc.
- Antibodies produced against the allergens are IgE type.
- Allergy is due to the release of chemicals like histamine and serotonin from the mast cells.
- Modern-day life style results lowering of immunity and more sensitivity to allergens.
- More children in India suffer from allergies and asthma due to sensitivity to the environment. This could be because of the protected environment provided early in life.
- **Symptoms of Allergy**
  (a) Sneezing.
  (b) Watery eyes.
  (c) Running nose.
  (d) Difficulty in breathing.
- **Treatment for Allergy:** Drugs like anti-histamine, adrenaline and steroids quickly reduce the symptoms of allergy.

Auto Immunity

- Sometimes due to the genetic and other unknown reasons, body attacks self-cell resulting into auto-immune disease. e.g., Rheumatoid arthritis.

Immune System in the Body

- It is the system that gives immunity to the body by recognizing, responding and remembering foreign antigens.
- It plays a key role in allergic reaction, auto-immune diseases and organ transplantation.
- It includes lymphoid organs, tissues, cells and soluble molecules like antibodies.

Lymphoid Organs

- These are the organs where origin, maturation and proliferation of lymphocytes occur.
- It is of two types namely : Primary lymphoid organs and secondary lymphoid organs.

(A) Primary Lymphoid Organs

- The primary lymphoid organs are bone marrow and thymus where immature lymphocytes differentiate into antigen-sensitive lymphocytes.

Bone Marrow and Thymus

- The bone marrow is the main lymphoid organ where all blood cells including lymphocytes are produced.
- The thymus is a lobed organ located near the heart and beneath the breastbone.
- The thymus is large at the time of birth but keeps reducing in size with age and by the time puberty is attained it reduces to a very small size.
- Both bone marrow and thymus provide micro-environments for the development and maturation of T-lymphocytes.

(B) Secondary Lymphoid Organs

- After maturation, the lymphocytes migrate to secondary lymphoid organs like spleen, lymph nodes, tonsils, Peyer's patches of small intestine and appendix.
- The secondary lymphoid organs provide the sites for interaction of lymphocytes with the antigen, which then proliferate to become effector cells.

Spleen

- The spleen is a large bean shaped organ.
- It mainly contains lymphocytes and phagocytes.
- It acts as a filter of the blood by trapping blood-borne micro-organisms.
- Spleen is also a large reservoir of erythrocytes.

Lymph Nodes

- The lymph nodes are small solid structures located at different points along the lymphatic system.
- Lymph nodes serve to trap the micro-organisms or other antigens, which happen to get into the lymph and tissue fluid.
- Antigens trapped in the lymph nodes are responsible for the activation of lymphocytes present there and cause the immune response.

MALT [Mucosal Associated Lymphoid Tissue]

- There is lymphoid tissue located within the lining of the major tracts (respiratory, digestive and urogenital tracts) called mucosal associated lymphoid tissue (MALT).
- It constitutes about 50 per cent of the lymphoid tissue in human body.

AIDS

- AIDS stands for Acquired Immuno Deficiency Syndrome. It damages our body's immune system, acquired during the lifetime of an individual indicating that it is not a congenital disease.
- The word 'syndrome' refers to a group of symptoms.
- It was first reported in 1981.
- It has spread all over the world killing more than 25 million persons.
- There is a time-lag between the infection and appearance of AIDS symptoms.
- It varies from months to years (5 – 10yrs).

Causes of AIDS

- It is caused by the Human Immuno deficiency Virus (HIV), a member of a group of viruses called retrovirus which have an envelope enclosing the RNA genome.
- It is transmitted
  (a) By sexual contact with infected person.
  (b) By transfusion of contaminated blood and blood products.
  (c) By sharing infected needles.
  (d) From infected mother to her child through placenta.
  (e) Through body fluids.
- So people having multiple sexual partners, drug addicts, individuals who require repeated blood transfusion and children born to an infected mother have high risk of getting this disease.
- It does not spread by touching, physical contact and hence it is imperative for the physical and psychological well-being, that the infected persons are not isolated from family and society.

Symptoms of AIDS

- The person suffers from bouts of fever, diarrhoea and weight loss.
- Due to decrease in the number of helper T-lymphocytes starts suffering from infections that could have been otherwise overcome such as those due to bacteria especially, *Mycobacterium*, viruses, fungi and parasites like *Toxoplasma*. The patient becomes so immuno-deficient that he/she is unable to protect himself/herself against these infections.

Test or Identification for AIDS

- It can be identified by ELISA (Enzyme Linked Immuno Sorbent Assay) test.

Treatment of AIDS

- The anti-retroviral drugs gives partial effect and can prolong the life of the patient but cannot prevent death, which is inevitable.

Replication of AIDS Virus

- After getting into the body of the person, the virus enters into macrophages where RNA genome of the virus replicates to form viral DNA with the help of enzyme reverse transcriptase.
- The viral DNA enters host cell's DNA and directs the infected cells to produce virus particles.
- The macrophages produce more and more virus and act as a HIV factory.
- Simultaneously, HIV enters into helper T-lymphocytes (T_H), replicates and produce progeny viruses.

- The progeny viruses released in the blood attack other helper T-lymphocytes resulting in the decrease in number of helper T-lymphocytes in the body and the person starts suffering from infections that could have been otherwise overcome.

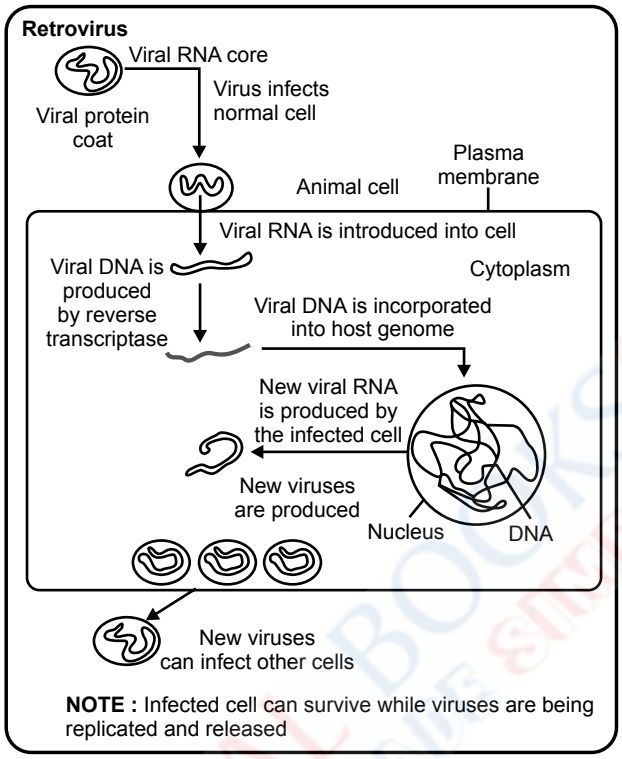

Fig. 1.3: Replication of retrovirus

Prevention of AIDS

- AIDS has no cure but can be prevented.
- The only excuse may be ignorance and it has been rightly said "don't die of ignorance".
- NACO (National AIDS Control Organization) and NGOs (Non-governmental Organization) are educating people about AIDS.
- WHO (World Health Organization) has started a number of programmes to prevent the spreading of HIV infection.

Steps to Prevent AIDS

(a) Using of disposable syringes and needles in private and public hospitals.
(b) Using condoms.
(c) Controlling drug abuse.
(d) Advocating safe sex.
(e) Promoting regular check-up

- HIV/AIDS infected people need help and sympathy instead of being shunned by society. Unless society recognizes it as a problem, the chances of spreading of disease increases manifold. It is difficult to be tackled, unless the society and medical fraternity act together, to prevent the spread of the disease.

CANCER

- It is one of the most dreaded diseases of human beings.
- It is a major cause of death all over the world.
- In cancer cells, the cell growth and differentiation are not controlled. Normal cells show a property called contact inhibition by virtue of which contact with other cells inhibits their uncontrolled growth.
- Cancer cells lose their property and continue to divide giving rise to mass of cells called tumors.
- Tumors are of two types namely, a) Benign and b) Malignant.
- **Benign tumors** remain in their original position and do not spread to other parts of the body causing little damage.

- **Malignant tumors** are a mass of proliferating cells called neoplastic or tumor cells which grow rapidly, invading and damaging the surrounding normal tissues.
- These cells starve the normal cells by competing for vital nutrients.
- Cells sloughed from such tumors reach distant sites through blood and whenever get lodged in the body, they start a new tumor. This property is called **metastasis.**

Causes of Cancer

- Normal cells can be transformed into cancerous cells by physical, chemical or biological agents which are called carcinogens.
- Ionizing radiations such as X-rays and gamma rays and non-ionizing radiations such as UV cause DNA damage.
- The chemical carcinogens in tobacco smoke are the major cause of lung cancer.
- The virus causing cancer is called oncogenic viruses which have genes called viral oncogenes.
- Several genes called cellular oncogenes (c-onc) or proto oncogenes in normal cells under certain conditions leads to oncogenic transformation of the cells.

Detection and Diagnosis of Cancer

- Cancer detection is based on biopsy and histopathological studies of the tissue, blood and bone marrow tests for increased cell counts as in the case of leukemia.
- In biopsy, a piece of the suspected tissue cut into thin sections is stained and examined under microscope by a pathologist.
- Techniques such as CT (Computed Tomography), radiography and MRI (Magnetic Resonance Imaging) are useful in detecting cancer in internal organs.
- CT uses X-rays to produce 3D image of the internal organs, MRI uses strong magnetic fields and non-ionising radiations to detect the changes in tissues.
- Antibodies against cancer-specific antigens are also used for detecting cancers.
- Molecular biology helps to detect genes in individuals with certain cancers. Such individuals are advised to avoid exposure to particular carcinogens to which they are susceptible, e.g., Tobacco smoke in case of lung cancer.

Treatment of Cancer

- The common approaches are surgery, radiation therapy and immunotherapy.
- In radiation therapy, the tumor cells are irradiated lethally, taking care of the normal tissues.
- Chemotherapeutic drugs are used to kill cancerous cells.
- Majority of the drugs has side effects like hair loss, anaemia etc.
- Some cancers are treated by combination of surgery, radiotherapy and chemotherapy.
- Tumor cells avoid detection and destruction by immune system. Therefore, the patients are given substances called biological response modifiers such as α-interferon which activates their immune system and helps in destroying the tumor.

Know the Terms

- **Health:** A state of complete physical, mental and social well-being.
- **NACO:** National AIDS Control Organization.
- **PMNC:** Polymorphonuclear cells.
- **WHO:** World Health Organization.
- **CMI:** Cell Mediated Immunity.
- **AIDS:** Acquired Immuno Deficiency Syndrome.
- **HIV:** Human Immuno Deficiency Virus.
- **MALT:** Mucosal Associated Lymphoid Tissue.
- **Antigens:** These are large and complex foreign molecules that activate the specific immune system to generate antibodies.
- **Antibodies:** These are the protein molecules produced in response to the antigens.
- **Cancer:** These are the uncontrolled division of cells that results due to the breakdown of regulatory mechanisms which govern the normal cell behaviour.

- **Disease:** It is the condition when the functioning of one or more organs of the body are adversely affected and characterized by various symptoms.
- **Immunity:** It refers to the overall ability of a living body to fight against diseases.
- **Interferons:** These are the glycoproteins produced by our body cells in response to a viral infection.
- **Metastasis:** It is the phenomenon in which cancer cells spread to different sites through the body fluids and develop secondary tumors.
- **Pathogens:** These are the organisms which cause diseases.
- **Retroviruses:** These are viruses which have RNA as genetic material, but can produce DNA by reverse transcription.
- **Syndrome:** It refers to a group of symptoms.
- **Tumors:** These are the masses of cells produced by the uncontrolled proliferation of cancerous cells.
- **Vaccination:** It is the process of introducing a preparation of antigenic proteins of pathogens or killed or inactivated pathogens into the body to generate the immune response.
- **Vectors:** These are the organisms which spread the pathogens of the same species, in which the inheritance of contrasting pairs of two traits is considered.

Mnemonics

Concept 1. Viral Diseases

Mnemonics: **I**nfluence the **Co**ol **M**anager **So** **Y**ou **C**ould **H**elp **MeP**acify **R**ich **S**eller **He**ro **Al**i to **G**et **D**iamonds (**I**nfluenza, **Co**mmon cold, **M**umps, **S**mallpox, **Y**ellow Fever, **C**hicken pox, **He**rpes, **Me**asles, **P**olio, **R**abies, **S**ARS, **He**patitis, **A**IDS, **G**astroentritis, **D**engue)

Interpretation

S.No.	Diseases
1.	Influenza
2.	Common cold
3.	Mumps
4.	Smallpox
5.	Yellow fever
6.	Chicken pox
7.	Herpes
8.	Measles
9.	Polio
10.	Rabies
11.	SARS
12.	Hepatitis
13.	AIDS
14.	Gastroentritis
15.	Dengue

Concept 2. Bacterial Diseases

Mnemonics: **Tip** **Tu** **CH**ahta **P**ehle **Dip** **Te**a **Le**aa (or) **T**ell **P**eter **To** **C**ome **P**lay and **D**ance **T**ill **L**ate (or) **T**ennis **P**layer **T**om **C**an **P**lay **D**ecently **T**ill the **L**ast

Interpretation

S.No.	Disease
1.	**T**yphoid
2.	**P**neumonia
3.	**T**uberculosis
4.	**C**holera
5.	**P**lague
6.	**D**iphtheria
7.	**T**etanus
8.	**L**eprosy

Concept 3. Detection and Diagnosis of Cancer

Mnemonics: **B**ook **R**eader **C**um**M**anager

Interpretation: **B**iopsy, **R**adiography, **CT**, **MRI**

Concept 4. Primary Lymphoid Organs

Mnemonics: **P**rofit **B**efore **T**ax (or) **P**lease **B**ook **T**ickets

Interpretation: **P**rimary: **B**one marrow, **T**hymus

Concept 5. Secondary Lymphoid organs

Mnemonics: **S**ee **S**akshi **L**ifting **T**ongs (or) **S**amosa **S**eems **L**ight and **T**asty

Interpretation: **S**pleen, **L**ymph node, **T**onsils

TOPIC-2
Adolescence and Drug/Abuse

Revision Notes

Introduction

- Adolescence means both 'a period' and 'a process' during which a child becomes mature in terms of his/her attitudes and beliefs for effective participation in society.
- The period between 12 – 18 years of age is said to be adolescence period.

- The term adolescence is a bridge linking childhood and adulthood.
- It is accompanied by biological and behavioural changes.
- Thus, adolescence is a vulnerable phase of mental and psychological development of an individual.
- Curiosity, excitement, experimentation and the adventure motivate youngsters towards drug and alcohol.
- Later the youngster starts using these to escape facing problems, stress, pressure to excel in academics etc.
- There is a perception among youth that it is 'cool' to smoke or use drugs.
- Television, movies, newspapers and internet helps to promote this perception.
- Other factors includes unsupportive family structures and peer pressure.

Drug Abuse

- The surveys and statistics show that the use of drugs and alcohol has been increased among youths.
- Proper education and guidance would enable youth to safeguard themselves against the drug abuse by following healthy life styles.
- The drugs commonly abused are opioids, cannabinoids and coca alkaloids.
- These drugs are obtained from flowering plants and fungi.

Opioids

- These drugs bind specific opioid receptors in the central nervous system and gastrointestinal tract. *e.g.*, – morphine and heroin.

(a) Morphine

- It is obtained from the latex of poppy plant (*Papaver somniferum*).
- It is sedative and pain killer.
- It is used to reduce pain after surgery.

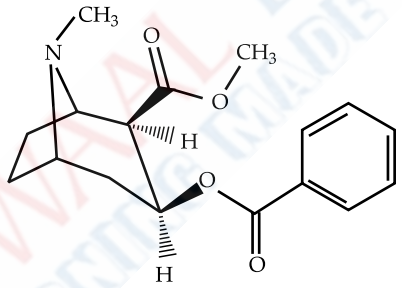

Fig. 1.4: Chemical Structure of Morphine

(b) Heroin

- It is commonly called *smack* and chemically called diacetylmorphine.
- It is bitter, white, odourless and crystalline compound obtained by acetylation of morphine.
- It is generally taken by snorting and injection.
- It is a depressant and slows down the body functions.

(c) Cannabinoids

- These are a group of chemicals which interact with cannabinoid receptors present mainly in the brain.
- Natural cannabinoids are obtained from the inflorescence of *Cannabis sativa.*
- Marijuana, hashish, ganja and charas are produced by the tops, leaves and resins of Cannabis plant.
- These are taken by inhalation and oral ingestion.
- These affect cardiovascular system of the body.

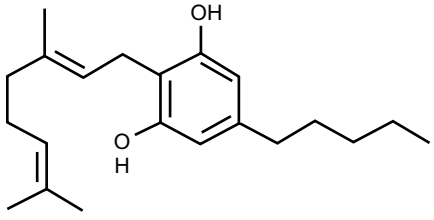

Fig. 1.5: Skeletal structure of cannabinoid molecule

Coca Alkaloid or Cocaine

- It is obtained from *Erythroxylum coca* native to South America.
- It interferes with the transport of the neurotransmitter dopamine.
- It is commonly called coke or crack.
- It is generally taken by snorting.
- It has a potential stimulating action on central nervous system producing a sense of euphoria and increased energy.
- Excessive dosage of cocaine causes hallucinations.
- These are abused by sports persons.
- Other plants having hallucinogenic properties are *Atropa belladonna* and *Datura.*
- Drugs like barbiturates, amphetamines, benzodiazepines, lysergic acid diethylamide [LSD] are abused.
- When these are taken for a purpose other than medicinal use or in high amounts, it impairs one's physical, physiological or psychological functions and constitutes drug abuse.

Tobacco

- Tobacco for more than 400 years is smoked, chewed or used as a snuff.
- It contains a large number of chemical substances including nicotine, an alkaloid.
- Nicotine stimulates adrenal gland to release adrenaline and nor-adrenaline into blood circulation, both of which raise blood pressure and increase heart rate.
- Smoking increases cancer in lungs, urinary bladder and throat, bronchitis, emphysema, coronary heart diseases, gastric ulcer etc.
- Tobacco chewing increases the risk of cancer of the oral cavity.
- Smoking increases CO content in blood and reduces the concentration of haem-bound oxygen thereby causing oxygen deficiency in the body.
- Smoking is prevalent in society, both among young and old. Knowing the dangers of smoking and chewing tobacco and its addictive nature, the youth and old need to avoid these habits.
- Addicted individuals requires counselling and medical help to get rid of this habit.

Addiction

- Addiction is a psychological attachment to certain effects such as euphoria and a temporary feeling of well-being associated with drugs and alcohol.
- It makes people to use it even when not required.
- With repeated use of drugs, the tolerance level of the receptors increases and the receptors respond to higher doses of drugs or alcohols leading to greater intake.
- Thus, the addictive potential of drugs and alcohol pull the user leading to regular use from which the person may be unable to get out.
- In absence of guidance and counselling, the person gets addicted and becomes dependent on them.

Dependence

- It is the tendency of the body to manifest a characteristic and unpleasant withdrawal syndrome if regular dose of drugs or alcohol is abruptly discontinued.
- It is characterized by anxiety, shakiness, nausea and sweating which may be relieved when its use is resumed again.
- Sometimes withdrawal symptoms becomes severe and even life threatening and the person may need medical supervision.
- Dependence leads the patient to ignore all social norms in order to get sufficient funds to satisfy his or her needs.
- It results in many social adjustment problems.

Effects of Drug/Abuse

- The immediate adverse effects of drug and alcohol abuse leads to reckless behaviour, vandalism and violence.
- Excessive doses of drug leads to coma and death due to respiratory failure, heart failure or cerebral haemorrhage.
- A combination of drugs result in overdosing and even death.
- The most common warning signs of drugs and alcohol abuse among youth are drop in academic performance, absence of school/college, lack of interest in personal hygiene, withdrawal, isolation, depression, fatigue,

aggressiveness, rebellious behaviour, deteriorating relationships with family and friends, loss of interest in hobbies, change in sleeping and eating habits, fluctuations in weight, appetite etc.

- The persons affected in absence of money steal to buy drugs or alcohol.
- Sometimes, a drug/alcohol addict becomes the cause of mental and financial distress to his/her entire family and friends.
- Those who take drugs intravenously i.e., by directly injecting into the vein using a needle or syringe acquire serious infections like AIDS and Hepatitis B.
- Both AIDS and Hepatitis B are chronic infections and leads to death.
- AIDS can be transmitted to one's life partner through sexual contact, while Hepatitis B is transmitted through infected blood.
- The chronic use of drugs and alcohol damages nervous system and liver (cirrhosis).
- The use of drugs during pregnancy affect the foetus.
- The narcotic analgesic drugs and steroids are misused by sportsperson's to improve the performance, increase muscle strength, to promote aggressiveness and increase athletic performance.
- The side-effects of the use of anabolic steroids in females include masculinisation, increased aggressiveness, mood swings, depression, abnormal menstrual cycle, excessive hair growth on the face and body, enlargement of clitoris and deepening of voice.
- In males it includes acne, increased aggressiveness, mood swings, depression, reduction of size of testicles, decreased sperm production, potential for kidney and liver dysfunction, breast enlargement, premature baldness, enlargement of prostrate gland.
- In adolescent males and females, severe facial and body acne and premature closure of growth centres of the long bones may result in stunted growth.

Prevention and Control of Drug/Abuse

- The habits such as smoking, taking drug taken up at a young age is more during adolescence.
- So, parents and the teachers have a special responsibility.
- Parenting with high levels of nurturance and consistent discipline reduces the risk of drug/abuse.

Some of the measures useful for prevention and control of alcohol and drug abuse are as follows:

(i) **Avoid undue peer pressure:** Every child should be respected for her/his personality and choice. He/she should not be pushed to perform beyond his/her threshold limits in studies, sports and other activities.

(ii) **Education and counselling:** Education and counselling helps him/her to face problems and stress and to accept disappointments and failures as a part of their life. Make them involve in other extra-curricular activities.

(iii) **Seeking help from parents and peers:** Parents and peers should help them immediately to give proper guidance and solution to sort out the problems to escape from anxiety and guilty.

(iv) **Looking for danger signs:** Teachers and friends should not hesitate to bring the habit to the notice of parents and the parents should take appropriate measures to diagnose the underlying cause to initiate proper remedial steps or treatment.

(v) **Seeking professional and medical help:** Highly qualified psychiatrist, psychologists conduct de-addiction and rehabilitation programmes to help individuals to overcome from drug/alcohol abuse and lead a normal and healthy life.

Know the Terms

- **NACO:** National AIDS Control Organization.
- **Adolescence:** It refers to the period and process of rapid growth and physical and mental development from childhood to adulthood.
- **Addiction:** It is a psychological attachment to certain effects such as euphoria and a temporary felling of well-being associated with drugs and alcohol.
- **Dependence:** It is the tendency of the body to manifest a characteristic and unpleasant withdrawal syndrome if regular dose of drugs or alcohol is abruptly discontinued.
- **Cirrhosis:** A chronic disease of the liver leading to degeneration of cells, inflammation, and fibrous thickening of tissue.
- **LSD:** Lysergic acid diethylamide.

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Chapter - 2 : Strategies for Enhancement in food Production

TOPIC-1
Plant Breeding, Single Cell Protein and Tissue Culture

Revision Notes

Plant Breeding

- It is the method where manipulation of plant species helps to create desired plant types that are better suited for cultivation, give better yields and are disease resistant.
- Plant breeding as a technology has helped us to increase yield in food production resulting in green revolution.
- 33% of India's Gross Domestic Product (GDP) comes from agriculture and it also employs about 62% of the population.

Types of Plant Breeding

- There are two main methods of plant breeding namely, conventional plant breeding and classical plant breeding.
- Conventional plant breeding has been practiced for thousands of years, since the beginning of human civilization.
- Classical plant breeding involves hybridization of pure lines and artificial selection to produce desirable traits of higher yield, nutrition and resistance to diseases.
- Now a days, plant breeding is carried out by using molecular genetic tools.

Desirable Traits

- **The following are the traits or characters that the breeders have tried to incorporate into crop plants:**
  (a) Increased crop yield.
  (b) Improved quality.
  (c) Increased tolerance to environmental stresses (salinity, extreme temperatures & drought), resistance to pathogens.
  (d) Increased tolerance to insect pests.

Steps in Breeding

(i) Collection of variability

- Genetic variability is the root of any breeding programme.
- The pre-existing genetic variability is available from wild relatives of many crops.
- The collection and preservation of all different wild varieties, species and relatives of the cultivated species is a pre-requisite for effective exploitation of natural genes.
- The entire collection of plants or seeds having all the alleles for all genes in a given crop is called germplasm collection.

(ii) Evaluation and selection of parents

- The germplasm is evaluated to identify plants with desirable combination of characters.
- Selected plants are multiplied and used for hybridisation.
- Pure lines are created wherever it is desirable and possible.

(iii) Cross hybridisation among the selected parents

- The desired characters are combined from two different plants (parents) to produce hybrids having the combined desired characters in a single plant.
- e.g., High protein quality of one parent is combined with disease resistance from another parent. On cross hybridization, it produces hybrids that genetically combine the desired characters in one plant.

- **Limitations of Cross Hybridisation**
  - **(a)** This is a very time-consuming process. Since the pollen grains from the desirable male plant have to be collected and placed on the stigma of the flowers selected as female parent.
  - **(b)** The hybrids may not combine the desirable characters. Usually only one in few hundred to a thousand crosses shows the desirable combination.

(iv) Selection and Testing of Superior Recombinants

- It includes the process of selection among the progeny of the hybrids of those plants that have the desired character combination.
- It is crucial to the success of the breeding objective and requires careful scientific evaluation of the progeny.
- It yields plants that are superior to both of the parents (Hybrid vigour).
- These are self-pollinated for several generations till they reach a state of uniformity (homozygosity), so that the characters will not segregate in the progeny.

(v) Testing, Release and Commercialization of New Cultivars

- The newly selected lines are evaluated for their yield and agronomic traits of quality, disease resistance, etc., by growing them in the research fields and recording their performance under ideal fertiliser application, irrigation and other crop management practices.
- Then the materials are tested in farmers' fields for at least three growing seasons at several locations in the country, representing all the agro climatic zones.
- The material is then evaluated in comparison to the best available local crop cultivar.

Indian Hybrid Crops

(a) Wheat and Rice

- During the period 1960-2000, wheat and rice production was increased due to the development of semi-dwarf varieties of wheat and rice.
- Nobel laureate Norman E. Borlaug, at International Centre for Wheat and Maize Improvement in Mexico, developed semi-dwarf wheat.
- Later, high yielding and disease resistant varieties such as Sonalika and Kalyan Sona were introduced all over the wheat-growing belt of India.
- Semi-dwarf rice varieties were derived from IR-8, (developed at International Rice Research Institute (IRRI), Philippines) and Taichung Native-1 (from Taiwan).
- Better-yielding semi dwarf varieties Jaya and Ratna were also developed in India.

(b) Sugarcane

- *Saccharum barberi*, grown in North India having poor sugar content and yield was crossed with *Saccharum officinarum*, grown in South India having thicker stems and higher sugar content. On crossing these two, a hybrid sugarcane having desirable qualities like high yield, thick stems, high sugar and ability to grow in North India was developed.

(c) Millets

- Hybrid maize, jowar and bajra were also developed in India.
- It includes high yielding varieties resistant to water stress.

Plant Breeding for Disease Resistance

- A wide range of fungal, bacterial and viral pathogens, affect the yield of cultivated crop species. Hence, breeding and development of cultivars resistant to disease helps to-
  - **(a)** Enhance the food production.
  - **(b)** Reduce the use of fungicides and bactericides.
- Resistance of the host plant is the genetic ability to prevent the pathogens from disease.
- For this, before breeding the causative organism and the mode of transmission is required.

Plant Diseases

- **Some plant diseases are as follows:**
  - **(a) Fungi:** Rusts (e.g., brown rust of wheat, red rot of sugarcane and late blight of potato).
  - **(b) Bacteria:** Black rust of crucifers.
  - **(c) Virus:** Tobacco mosaic, turnip mosaic etc.

Methods of Breeding for Disease Resistance

- It includes two types namely, conventional breeding and mutation breeding.

(a) Conventional Method:

- **The steps are:**
  - **(a)** Screening germplasm for resistance sources.
  - **(b)** Hybridisation of selected parents.
  - **(c)** Selection and evaluation of the hybrids.
  - **(d)** Testing and release of new varieties.
- **The following tabular column shows the crop varieties breed by conventional method:**

Crop	Variety	Resistance to
Wheat	Himgiri	Leaf & stripe rust, hill blunt
Brassica	Pusa swarnim (Karan rai)	White rust
Cauliflower	Pusa Shubhra, Pusa Snowball K-1	Black rot and Curl blight black rot
Cowpea	Pusa Komal	Bacterial blight
Chilli	Pusa Sadabahar	Chilly mosaic virus, Tobacco mosaic virus, and leaf curl.

Mnemonics

Concept: Crop variety resistance to diseases

Crop	Variety	Resistance to disease
Wheat	Himgiri	Leaf and stipe rust, hill blunt.

Mnemonics : What a **H**ilarious **S**mi**L**e? **H**eavenly beautiful

Interpretation:

W - Wheat **H** - Himgiri **L** - Leaf rust
S - Stipe rust **H** - Hill blunt **B** - Blunt

Mnemonics

Concept: Conventional Method

Mnemonics: Some **G**oes **H**igher **S**eeking **E**ssence of **T**alent **R**esponding

Interpretation:

(a) Screening **G**ermplasm for resistance sources.
(b) Hybridisation of selected parents.
(c) Selection and **E**valuation of the hybrids.
(d) Testing and release of new varieties.

- Conventional breeding is constrained by the availability of limited number of disease resistance genes in the crop varieties.
- Inducing mutations in plants and then screening the plant materials for resistance help to identify the desirable genes.
- Plants having these desirable characters can then be either multiplied directly or can be used in breeding.

(b) Mutation Breeding

- Mutation is the process by which genetic variations are created through changes in the base sequence within genes resulting in the creation of a new character or trait not found in the parental type.
- Mutation is induced by using chemicals or radiations (like gamma radiations) and selecting the plants that have desirable character as source in breeding.

- e.g., In mung bean, the resistance to yellow mosaic virus and powdery mildew were induced by mutations.
- Since different cultivated species show certain resistant characters with low yield, resistant genes from wild species are introduced into the high-yielding cultivated varieties.
- e.g., Resistance to yellow mosaic virus in bhindi (*Abelmoschus esculentus*) was transferred from a wild species and resulted in a new variety called *Parbhani Kranti*.
- Transfer of resistance genes is achieved by sexual hybridization between the target and the source plant.

Plant Breeding for Developing Resistance to Insect Pests

- Insect resistance in host crop plants may be due to morphological, biochemical or physiological characteristics.
  - **(a)** Hairy leaves : e.g., resistance to jassids in cotton and cereal leaf beetle in wheat.
  - **(b)** Solid stems in wheat : non-preference by the stem sawfly.
  - **(c)** Smooth leaved and nectar-less cotton varieties do not attract bollworms.
  - **(d)** High aspartic acid, low nitrogen and sugar content in maize leads to resistance to maize stem borers.
- **The tabular column below shows some crop varieties breed for insect pest resistance :**

Crop	Variety	Resistance to
Brassica (rapeseed mustard)	*Pusa Gaurav*	Aphids
Flat bean	*Pusa Sem 2*, *Pusa Sem 3*	Jassids, aphids & fruit borer.
Okra (Bhindi)	*Pusa Sawani*, *Pusa A-4*	Shoot and Fruit borer

Plant Breeding for Improved Food Quality

- A majority of people in our country suffer from micronutrient, protein and vitamin deficiencies or 'hidden hunger' because they cannot afford to buy enough fruits, vegetables, legumes, fish and meat.
- **Single Cell Protein (SCP):** It is an alternate source of proteins for animal and human nutrition. *e.g.*, microbes like *Spirulina*.
- *Spirulina* is rich in protein, minerals, fats, carbohydrate & vitamins.
- It is grown on materials like waste water from potato processing plants, straw, molasses, animal manure & sewage. This also reduces environmental pollution.
- A 250 Kg cow produces 200 g of protein/day. In the same period, 250 g of a micro-organism like *Methylophilus methylotrophus* produce 25 tonnes of protein.

Tissue Culture

- It is a technique of growing plant cells/tissues/organs in sterile culture medium under controlled aseptic conditions.
- The ability to generate a whole plant from any cell/explant is called totipotency.
- An explant is any part of a plant that is grown in a test tube under sterile nutrient media.
- The nutrient medium must provide a carbon source (such as sucrose), inorganic salts, vitamins, amino acids and growth regulators like auxins, cytokinins etc.
- The method of producing thousands of plants in very short time through tissue culture is called micropropagation.
- These plants will be genetically identical to original plant, from which they were grown, *i.e.,* they are somaclones.
- Tomato, banana, apple etc. are produced using this method.
- Tissue culture is also used for recovering healthy plants from diseased plants.
- The meristem which is free of virus from infected plant is removed and grown it in vitro to obtain virus-free plants.
- Scientists have cultured meristems of banana, sugarcane, potato, etc.

Somatic Hybridization

- Protoplasts from two different varieties of plants (with desirable characters) are fused to get hybrid protoplasts.
- It can be grown to form a new plant called somatic hybrids. This process is called somatic hybridization.
- Protoplasts can be isolated after digesting the cell walls of single cells of plants.
- A protoplast of tomato has been fused with that of potato, to form new hybrid plants with the characteristics of tomato and potato called pomato.
- However, this plant did not have all the desired combination of characteristics for its commerical utilization.

Know the Terms

- **Explant:** It is the part of plant excised from a specific location in a plant to be used for initiating a culture.
- **Micropropagation:** It is the method of producing plants through tissue culture.
- **Plant Breeding:** It is the manipulation of plant species to obtain desired plant types better suited for cultivation, give better yields and disease resistant.
- **Plant Tissue culture:** It refers to the regeneration of whole plant from any cell or tissue or organ of a plant on a suitable synthetic medium in-vitro.
- **Somaclones:** These are the genetically identical plants developed from any part of the plant by tissue culture or micropropagation.
- **Somatic Hybridisation:** It is the process of fusion of protoplasts of somatic cells derived from two different varieties or species of plants on a suitable nutrient culture medium.
- **Heterosis:** Heterosis or hybrid vigour is the exhibition of superiority of the hybrid offspring over both of its parents in one or more traits such as the ability to give higher yield or disease or pest resistance.
- **Mutation:** The genetic variations are created through changes in the base sequence within genes.
- **SCP:** Single Cell Protein.
- **Totipotency:** The ability of a living cell to express all of its genes to regenerate a whole new individual.
- **Explant:** It is a cell, organ, or piece of tissue which has been transferred from animals or plants to a special nutrient medium.
- **IRRI:** International Rice Research Institute**.**

TOPIC-2
Animal Husbandry and Apiculture

Revision Notes

Introduction

- Biological principles such as animal husbandry and plant breeding have a major role in increasing the food production.
- There are several new techniques like embryo transfer technology and tissue culture techniques that are going to play a pivotal role in enhancing food production.

ANIMAL HUSBANDRY

- It is the process of agricultural practice of breeding and raising livestock.
- It deals with the care & breeding of livestock such as buffaloes, cows, pigs, horses, cattle, sheep, camels, goats, bees, silkworms etc., and also poultry farming and fisheries.
- Fisheries include rearing, catching, selling etc. of fish, molluscs like shell-fish and crustaceans like prawns, crabs, etc.
- Since time immemorial animals like bees, silk-worm, prawns, crabs, fishes, birds, pigs, cattle, sheep and camels have been used by humans for products like milk, eggs, meat, wool, silk, honey, etc.
- More than 70% of the world livestock population is in India and China.
- The contribution of farm produce to the world is only 25%, i.e., the productivity per unit is very low.
- Hence, new technologies have to be applied to achieve improvement in quality and productivity.

Management of Farms and Farm Animals

- A professional management procedures/approach to the traditional practices of farm management will enhance the food production in the country.

  Dairy Farm Management (Dairying)

  - Dairying is the management of animals for milk and its products for human consumption.
  - It deals with the processes and systems that increase yield and improve quality of milk.
  - The yield of milk depends on the quality of breeds in the farm.
  - Good breeds having high yielding potential and resistance to diseases are selected.

- **For the yield potential to be realized :**
  - **(a)** The cattle have to be looked after well.
  - **(b)** They have to be housed well.
  - **(c)** They should have adequate water.
  - **(d)** They should be maintained in disease free condition.
  - **(e)** The feeding of cattle should be carried out in a scientific manner and with special emphasis on the quality and quantity of fodder.
  - **(f)** Stringent cleanliness and hygiene (of cattle & handlers) while milking, storage and transport of the milk should be maintained.
- However, these processes have been mechanized and so it has reduced the chance of direct contact of the produce with the handler.
- **To ensure these stringent measures there should be :**
  - **(a)** Regular inspections, with proper record keeping. It also helps to identify and rectify the problems.
  - **(b)** Regular visits by a veterinary doctor.

Animal Breeding

- A breed is a group of animals related by descent and similar in most characters like general appearance, features, size etc.
- Breeding is the modification of genotype of an organism to make that organism more useful to humans.
- Animal breeding aims at increasing the yield of animals and improving the desirable qualities of the produce.
- There are two types of breeding namely, inbreeding and out-breeding.

(a) Inbreeding

- It is the process of mating more closely related individuals within the same breed for 4-6 generations.
- Superior males and superior females of the same breed are identified and mated in pairs.
- The progeny obtained are evaluated and superior males and females among them are identified for further mating.
- In cattle, a superior female is the one that produces more milk per lactation whereas a superior male (bull) is the one which gives rise to superior progeny.
- **Advantages of Inbreeding :**
  - **(a)** It increases homozygosity to evolve a pureline animal.
  - **(b)** It exposes harmful recessive genes that are eliminated by selection.
  - **(c)** It helps in accumulation of superior genes and elimination of less desirable genes. This approach increases the productivity of inbred population.
- **Disadvantage of Inbreeding :**
  - **(i)** Continued inbreeding, especially close inbreeding, may reduce fertility and productivity. This is called inbreeding depression.
  - **(ii)** To solve this problem, selected animals of the breeding population should be mated with unrelated superior animals of the same breed which helps to restore fertility and yield.

(b) Out-breeding

- It is the breeding of the unrelated animals which may be between individuals of the same breed (but having no common ancestors), or between different breeds (cross-breeding) or different species (inter-specific hybridization).
- It includes out-crossing, cross-breeding and inter-specific hybridization.

(i) Out-crossing

- It is the practice of mating of animals within the same breed having no common ancestors on either side of their pedigree up to 4-6 generations.
- The offspring formed is known as out-cross.
- It is the best breeding method for animals having low productivity in milk production, growth rate in beef cattle, etc.
- It helps to overcome inbreeding depression.

(ii) Cross-breeding

- In this method, superior males of one breed are mated with superior females of another breed.

- It allows the desirable qualities of two different breeds to combine to form the progeny hybrid animals that may be used for commercial production or may be subjected to inbreeding and selection to develop new stable superior breeds.
- e.g., *Hisardale* (sheep) developed in Punjab by crossing *Bikaneri ewes* and *Marino rams*.

(iii) Interspecific hybridization

- It is the mating of male and female animals of two different species.
- The progeny formed may combine desirable features of both the parents, and may be of considerable economic value.
- e.g., Mule (Male ass × Female horse).

CONTROLLED BREEDING EXPERIMENTS

(a) Artificial insemination (AI)

- The controlled breeding experiments are carried out using artificial insemination.
- In this process, the semen collected from male parent is injected into the reproductive tract of selected female by the breeder.
- The semen may be used immediately or can be frozen and used later.
- It can also be transported in a frozen form to where the female is housed to obtain desirable hybrid.
- Success rate of crossing mature male & female animals is low even though artificial insemination is carried out.
- **Advantages of artificial insemination :**
  - **(i)** Semen can be transported in frozen form to a distant place.
  - **(ii)** Semen from selected male animal can be used on a number of female animals.

(b) Multiple Ovulation Embryo Transfer Technology (MOET)

- It is a programme for herd improvement i.e., to improve the chances of successful production of hybrids.
- In this process, a cow is administered with hormones like FSH to induce follicular maturation and super ovulation to produce 6-8 eggs per cycle instead of one egg.
- The animal is either mated with an elite bull or artificially inseminated.
- Then the fertilised eggs at 8–32 celled stages are recovered and transferred to surrogate mothers.
- This technology has been demonstrated for cattle, sheep, rabbits, buffaloes, mares, etc.
- High milk yielding breeds of females and high quality (lean meat with less lipid) meat-yielding bulls have been bred successfully to increase herd size in a short time.

BEE-KEEPING (APICULTURE)

- It is the process of maintenance of hives of honeybees for the production of honey and beeswax.
- Honey is a food of high nutritive and medicinal value.
- Honeybee produces beeswax which is used in the preparation of cosmetics, polishes etc.
- The increased demand of honey has led to large-scale bee-keeping practices as income generating industry.
- Bee-keeping can be practiced in area where there are sufficient bee pastures of some wild shrubs, fruit orchards and cultivated crops.
- Most common species that can be reared is *Apis indica*.

Important Features for Successful Bee-keeping

- **Bee-keeping though relatively easy does require some specialized knowledge as follows:**
  - **(i)** Knowledge of the nature and habits of bees.
  - **(ii)** Selection of suitable location for keeping beehives.
  - **(iii)** Catching and hiving of swarms (group of bees).
  - **(iv)** Management of beehives during different seasons.
  - **(v)** Handling and collection of honey and of beeswax.
- Bees are the pollinators of many of our crop species such as sunflower, *Brassica*, apple and pear.
- Keeping beehives in crop fields during flowering period increases pollination which thereby improves crop and honey yield.

FISHERIES

- It deals with catching, processing or selling of fish, shellfish or other aquatic animals (prawn, crab, lobster, edible oyster etc).
- It includes,
  - **(a) Freshwater fishes :** *Catla*, *Rohu*, common carp, etc.
  - **(b) Marine fishes :** *Hilsa*, Sardines, Mackerel, Pomfrets, etc.
- Fisheries provide income and employment to fishermen and farmers.
- There are two main techniques namely, aquaculture and pisciculture, which helps to increase the production of aquatic plants and animals.
- The culturing of all aquatic organisms in fresh water, brackish and marine environment is called aquaculture.
- Pisciculture is breeding and rearing of only fishes in water bodies for commercial purposes.
- The development and flourishing of the fishery industry is known as blue revolution.

Know the Terms

- **Animal husbandry:** It is the agricultural practice of breeding and raising livestock useful to humans.
- **Apiculture:** It is the maintenance of hives of honeybees for the production of honey.
- **Breed:** It is a group of animals of same species that are similar in most of their characters.
- **Cross breeding:** It is a method of out-breeding in which superior males of one breed are mated with the superior females of another breed of the same species.
- **Dairying:** It is the management of animals for milk and milk products for human consumption.
- **Fishery:** It is an industry dealing with catching, rearing, processing and selling of fishes, molluscs, crustaceans etc., and their products.
- **Apiculture:** The maintenance of hives of honeybees for the production of honey.
- **Germplasm:** It is the sum total of all the alleles of the genes present in an individual organism and its related species.
- **Inbreeding:** It refers to the mating of more closely related individuals within the same breed.
- **Interspecific hybridisation:** It is the method of out-breeding in which the male and the female animals of two different species are crossed.
- **Inbreeding depression:** It is the loss in vigour and fertility associated with inbreeding.
- **Out-breeding:** It is the breeding of unrelated animals either of same or of different breeds or even different species.
- **Outcrossing:** It is the practice of mating of animals within the same breed having no common ancestors on either side upto 4-6 generations.
- **Poultry:** It is the class of domesticated fowl used for food or for their eggs.
- **MOET:** Multiple Ovulation Embryo Transfer Technology.
- **Aquaculture:** The culturing of all aquatic organisms in fresh water, brackish and marine environment.
- **Pisciculture:** The breeding and rearing of only fishes in water bodies for commercial purposes.

Mnemonics

Concept: Fisheries
1. **Mnemonics: C**ivil **R**ight **C**enter **Interpretation :** Freshwater fishes - Catla, Rohu, Common carp
2. **Mnemonics: H**igh **S**peed **M**achine **Interpretation:** Marine fishes - Hilsa, Sardines, Mackerel

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UNIT-4 : BIOTECHNOLOGY AND ITS APPLICATIONS

Chapter-3 : Biotechnology–Principles and Processes

TOPIC-1

Principles of Biotechnology and Tools of Recombinant DNA Technology

Revision Notes

Biotechnology

- Biotechnology deals with techniques of using live organisms or their enzymes for products and processes that are useful to humans.
- **Biotechnology deals with :**
  - **(a)** Microbe-mediated processes (making curd, bread, wine, etc).
  - **(b)** *In vitro* fertilization ('test-tube' baby programme).
  - **(c)** Synthesis and using of a gene.
  - **(d)** Preparation of a DNA vaccine.
  - **(e)** Correcting a defective gene.
- The European Federation of Biotechnology (EFB) defines biotechnology as 'the integration of natural science and organisms, cells, parts thereof, and molecular analogues for products and services'.
- **Modern biotechnology is based on the two core techniques :**
  - **(a) Genetic Engineering :** It is the technique in which the genetic material i.e., DNA and RNA is chemically altered and introduced into host organisms to change the phenotype.
  - **(b) Maintenance of Sterile Ambience :** It is necessary in chemical engineering processes for growing only the desired microbe/eukaryotic cell in large quantities for the manufacture of antibiotics, vaccines, enzymes, etc.

Conceptual Development of the Principles of Genetic Engineering

- The advantage of sexual reproduction is that it provides opportunities for variations and formulation of unique combinations of genetic setup, some of which may be beneficial to the organism as well as the population.
- The advantage of asexual reproduction is that it preserves the genetic information.
- Traditional hybridization techniques lead to inclusion and multiplication of undesirable genes along with desired genes.
- The techniques of genetic engineering which include creation of recombinant DNA, use of gene cloning and gene transfer, overcome the limitation of traditional hybridization techniques and allows us to isolate and introduce only the desirable genes into the target organism.
- A piece of DNA is not able to multiply itself in the progeny cells of the organism. But, when it gets integrated into the recipient genome, it multiplies and inherits along with the host DNA.
- This is because the alien piece of DNA has become part of a chromosome, which has the ability to replicate.
- In chromosome, there is a specific DNA sequence called the origin of replication, which is responsible for initiating replication. In genetic engineering, the foreign DNA is linked with the origin of replication, so that the foreign DNA can replicate and multiply itself in the host organism, which is also known as cloning or making multiple identical copies of any template DNA.

Formation of First Recombinant DNA

- First recombinant DNA was emerged from the possibility of linking a gene of antibiotic resistance with a natural plasmid of *Salmonella typhimurium*.
- Stanley Cohen & Herbert Boyer (1972) isolated the antibiotic resistance gene by cutting out a piece of DNA from a plasmid which was responsible for conferring antibiotic resistance.
- The cutting of DNA at specific locations became possible with the discovery of 'molecular scissors' called the restriction enzymes.
- The cut piece of DNA was then linked with the plasmid DNA, which act as vectors to transfer the piece of DNA attached to it.
- The linking of antibiotic gene with the plasmid vector became possible with the enzyme ligase, which acts on cut DNA molecules and joins their ends. This makes a new combination of autonomously replicating DNA created *in vitro* and is known as recombinant DNA.
- When this DNA is transferred into *Escherichia coli*, a bacterium closely related to *Salmonella*, it could replicate using the new host's DNA polymerase enzyme and make multiple copies.
- The ability to multiply copies of antibiotic resistance gene was called cloning of antibiotic resistance gene in *E. coli*.

Steps Involved in Genetically Modifying an Organism

(a) Identification of DNA with desirable genes.

(b) Introduction of the identified DNA into the host.

(c) Maintenance of introduced DNA in the host and transfer of the DNA to its progeny.

Tools of Recombinant DNA Technology

(a) Restriction enzymes.

(b) Polymerase enzymes.

(c) Ligases.

(d) Vector and

(e) Host organism.

Restriction Enzymes ('Molecular Scissors')

- In 1963, two enzymes responsible for restricting the growth of bacteriophage in *E. coli* were isolated.
- One of these added methyl groups to DNA while the other (restriction endonuclease) cut DNA.
- **Naming of the restriction enzymes:** First letter indicates genus and the second two letters indicate species of the prokaryotic cell from which they were isolated.
- Restriction enzymes belong to a class of enzymes called nucleases.

Mnemonics

Concept: Enzymes Used in Biotechnology	
Mnemonics: LILY Rose Scent : Rose Daisy Carnation Sunflower	
Interpretation: Enzymes : Uses	
DNA Ligase : DNA **R**epair enzyme	**L**yases : **D**issolve cell wall
Restriction enzymes : **C**leaves DNA	**S**ynthetase : In-vitro DNA **S**ynthesis

- **Nucleases can be classified into two types :**
  - **(a) Exonucleases :** They remove nucleotides from the ends of the DNA.
  - **(b) Endonucleases :** They cut at specific positions within the DNA.
- Each restriction endonuclease can bind to specific recognition sequence of the DNA and cut each of the two strands at specific points in their sugar-phosphate backbones.
- Each restriction endonuclease recognizes a specific palindromic nucleotide sequences in the DNA.

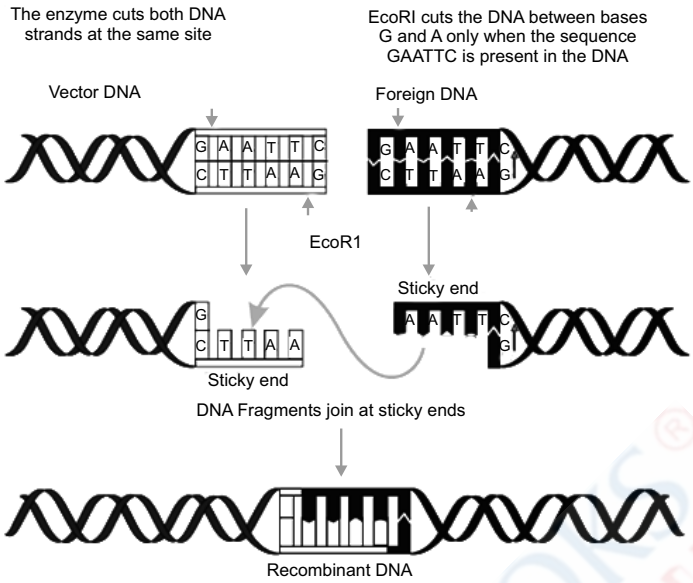

Fig. 3.1: Action of Restriction Endonuclease Enzyme to from Recombinant DNA

- The palindrome in DNA is a sequence of base pairs that read the same on the two strands in 5′ → 3′ direction and in 3′ → 5′ direction.

  Example:

  5′ —— GAATTC —— 3′

  3′ —— CTTAAG —— 5′

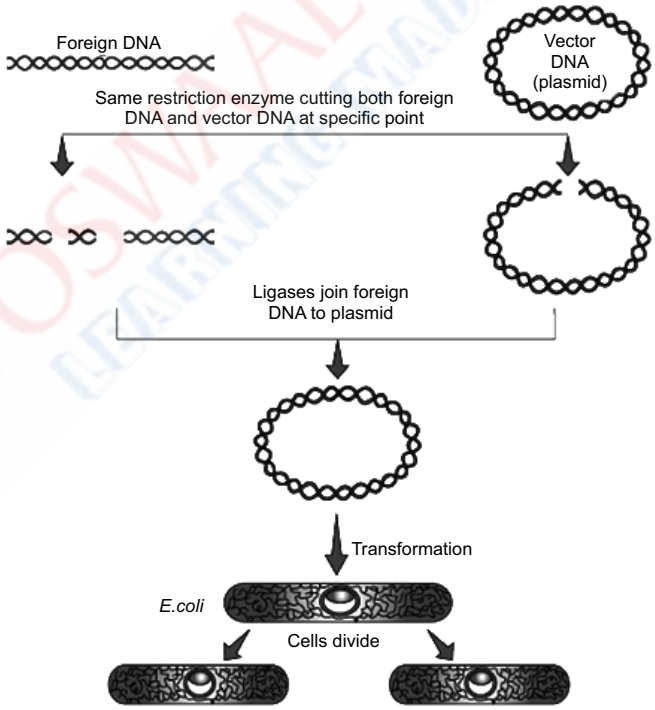

Fig. 3.2: Diagrammatic Representation of Recombinant DNA Technology

- Restriction enzymes cut the strand a little away from the centre of the palindrome sites, but between the same two bases on the opposite strands.
- This leaves single stranded over hanging stretches called sticky ends on each strand.
- They form H-bonds with their complementary cut counterparts with the help of the enzyme **DNA ligase**.
- When cut by the same restriction enzyme, the resultant DNA fragments have the same kind of sticky-ends and these are joined together by DNA ligases.

- It is important to note that unless one cuts the vector and the source DNA with the same restriction enzyme, the recombinant vector molecule cannot be created.

Separation and Isolation of DNA Fragments

- DNA fragments formed by restriction endonucleases can be separated by a technique called gel electrophoresis.
- DNA fragments are negatively charged and hence can be separated by moving them towards the anode under an electric field through a medium/matrix such as agarose, a natural polymer extracted from sea weeds.
- The DNA fragments separate (resolve) according to their size through sieving effect provided by the agarose gel.
- The smaller sized fragment move farther.
- The separated DNA fragments can be visualized after staining the DNA with ethidium bromide followed by exposure to UV radiation. Bright orange coloured DNA bands can be seen.
- The separated DNA bands are cut out from agarose gel and extracted from gel piece. This step is called **elution**.
- These purified DNA fragments are used in constructing recombinant DNA by joining them with cloning vectors.

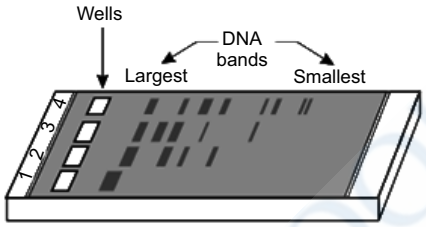

Fig. 3.3: Agarose Gel Electrophoresis

Cloning Vectors

- These are the DNA molecules that can carry a foreign DNA segment and replicate inside the host cells.
  e.g. Plasmids, a circular extra-chromosomal DNA of bacteria and bacteriophages.
- Bacteriophages have very high copy numbers of their genome within the bacterial cells.
- Some plasmids have only 1-2 copies per cell. Others may have 15-100 copies per cell.
- When the cloning vectors are multiplied in the host, the linked piece of DNA also gets multiplied to the number equal to the copy number of the vectors.
- **Features of Cloning Vector**

(a) Origin of Replication (ori)

- This is a sequence from where replication starts.
- A piece of DNA linked to *ori* can replicate within the host cells and also controls the copy number of the linked DNA.
- In order to get many copies of the target DNA, it should be cloned in a vector whose origin supports high copy number.

(b) Selectable Marker (Marker Gene)

- It helps to select the transformants and eliminate the non-transformants.
- Transformation is a procedure in which a piece of DNA is introduced in a host bacterium.
- Selectable markers of *E. coli* include the genes encoding resistance to antibiotics like ampicillin, chloramphenicol, tetracycline or kanamycin, etc.
- The normal *E. coli* cells not carry resistance against any of these antibiotics.

(c) Cloning Sites

- To link the alien DNA, the vector needs very few recognition sites for restriction enzymes.
- Presence of more than one recognition sites generates several fragments, which complicates the gene cloning.
- The ligation of alien DNA is carried out at a restriction site present in one of the two antibiotic resistance genes.

  e.g., Ligation of a foreign DNA at the BamH I site of tetracycline resistance gene in the vector pBR322.

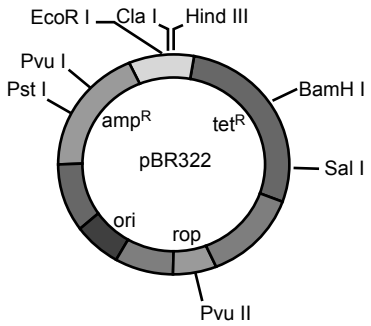

Fig. 3.4: *E. coli* cloning vector pBR322 showing restriction sites

- The recombinant plasmids lose tetracycline resistance due to insertion of foreign DNA.
- But they can be selected out from non-recombinant ones by plating the transformants on ampicillin containing medium.
- Then, these transformants are transferred on tetracycline medium.
- The recombinants grow in ampicillin medium but not on tetracycline medium.
- But, non-recombinants will grow on the medium containing both the antibiotics.
- In this case, one antibiotic resistance gene helps to select the transformants whereas the other antibiotic resistance gene gets inactivated due to insertion of alien DNA and helps in selection of recombinants.
- Selection of recombinants due to inactivation of antibiotic requires simultaneous plating on two plates having different antibiotics. This is a cumbersome procedure.
- Therefore, alternative selectable markers have developed to differentiate recombinants from non-recombinants on the basis of their ability to produce colour in the presence of a chromogenic substrate.
- A recombinant DNA is inserted within the coding sequence of an enzyme, β-galactosidase and so the enzyme become inactivated which is called insertional inactivation.
- If the plasmid in the bacteria has an insert, it results in insertional inactivation of the β-galactosidase and hence the colonies do not produce any colour and are identified as recombinant colonies.
- If the plasmid in bacteria have no insert it gives blue coloured colonies in presence of chromogenic substrate.

Vectors for Cloning Genes in Plants and Animals

- Genetic materials of some pathogens can be transformed into useful vectors for delivering genes to plants and animals.

Example 1

- *Agrobacterium tumefaciens*, a pathogen of many dicot plants can deliver a piece of DNA (t-DNA) to transform normal plant cells into a tumor.
- These tumor cells produce the chemicals required by the pathogen.
- The tumor inducing (Ti) plasmid of *A. tumefaciens* is modified into a cloning vector which is not pathogenic to the plants but is able to use the mechanisms to deliver genes of our interest into plants.

Example 2

- Retroviruses are used to deliver desirable genes into animal cells.
- So, once a gene or a DNA fragment has been ligated into a suitable vector, it is transferred into a bacterial, plant or animal host (where it multiplies).

Competent Host (For Transformation with Recombinant DNA)

- DNA is a hydrophilic molecule and hence it cannot pass through cell membrane.
- Due to this, the bacterial cells are treated with a specific concentration of a divalent cation such as calcium to allow DNA to pass through pores in cell wall of bacterium.
- Such cells are incubated with recombinant DNA on ice.
- Then they are placed at 42°C (heat shock) and put them back on ice to enable the bacteria to take up the recombinant DNA.
- **Different Methods to Introduce Alien/Foreign DNA into Host Cells are :**

(a) Micro-injection

- In this method, the recombinant DNA is directly injected into the nucleus of an animal cell.

(b) Biolistics (Gene Gun)

- In this method, the cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA. This method is suitable for plants.

(c) 'Disarmed Pathogen' Vectors

- When these vectors infect the cell, it transfers the recombinant DNA into the host.

Know the Terms

- **Biolistics or Gene Gun :** Plant cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA.
- **Exonucleases :** It removes nucleotides from the ends of the DNA molecule.
- **Endonucleases :** It cuts at specific positions within the DNA molecule.
- **Genetic Engineering :** Techniques to alter the chemistry of genetic material (DNA and RNA), to introduce these into host organisms and thus change the phenotype of the host organism.
- **Gene Cloning :** It refers to the method of obtaining identical copies of a particular DNA segment or a gene.
- **Origin of Replication (ori) :** A specific DNA sequence which is responsible for initiating replication.
- **Plasmid :** Autonomously replicating circular extra-chromosomal DNA of any bacteria.
- **Palindromic Nucleotide Sequences :** The palindrome in DNA is a sequence of base pairs that reads same on the two strands when orientation of reading is kept the same.
- **Recombinant Protein :** It is the protein produced by the expression of rDNA in the transgenic organism.
- **Restriction Enzymes :** Enzymes that are used to cut DNA segment at a specific site are called restriction enzymes.
- **Recombinant Site or Sequence :** It is the specific base sequence of DNA where the restriction enzyme cuts the DNA.
- **Recombinant DNA :** It is the DNA formed by combining DNA from two different organisms.
- **Gene Transfer :** The insertion of unrelated genetic information in the form of DNA into cells
- **Gel electrophoresis :** The technique used to separate the fragments of DNA.
- **Transformation :** The procedure through which a piece of DNA is introduced in a host bacterium.
- **Selectable marker :** It is a gene introduced into a cell, mainly a bacterium or to cells in culture, that confers a trait suitable for artificial selection.
- **Competent host :** It is a cell which is capable of taking up an alien DNA.

TOPIC-2
Process of Recombinant DNA Technology

Revision Notes

- **Recombinant DNA technology involves several steps in specific sequence as follows :**
  - **(a)** Isolation of DNA.
  - **(b)** Fragmentation of DNA by restriction endonucleases.
  - **(c)** Isolation of a desired DNA fragment.
  - **(d)** Ligation of the DNA fragment into a vector.
  - **(e)** Transferring the recombinant DNA into the host.
  - **(f)** Culturing the host cells in a medium at large scale and extraction of the desired product.

A. Isolation of the Genetic Material (DNA)

- In order to obtain DNA free from other macro-molecules such as RNA, proteins, polysaccharides and lipids, the bacterial cells/plant or animal tissue are treated with enzymes such as lysozyme (bacteria), cellulase (plant cells), chitinase (fungus) etc.
- The cell is broken to release DNA along with other macromolecules.
- Genes on the DNA are intertwined with proteins such as histones.
- RNA is removed by treating with ribonuclease.

- Proteins are removed by treatment with protease.
- Other molecules are removed by appropriate treatments.
- The purified DNA precipitates out as a collection of fine threads in the suspension when chilled ethanol is added.

B. Cutting of DNA at Specific Locations

- Restriction enzyme digestions are performed by incubating purified DNA with the restriction enzyme, at optimal conditions for the specific enzyme.
- Agarose gel electrophoresis is employed to check the progression of a restriction enzyme digestion.
- Since DNA is negatively charged, it moves towards the anode.
- The process is repeated with the vector DNA also.
- After cutting the source DNA and the vector DNA, the cut out gene (DNA segment) of interest from the source DNA and the cut vector are mixed and ligase is added.
- This creates recombinant DNA.

C. Amplification of Gene of Interest using PCR

- Polymerase Chain Reaction (PCR) is the synthesis of multiple copies of the gene of interest *in vitro* using two sets of primers and the enzyme DNA polymerase.
- Primers are small chemically synthesized oligonucleotides that are complementary to the regions of DNA.
- The enzyme extends the primers using the nucleotides and the genomic DNA (template).
- By continuous DNA replication, the DNA segment is amplified upto 1 billion copies.
- For repeated amplification, a thermostable DNA polymerase is isolated from a thermophilic bacterium, *Thermus aquaticus*, which remains active during high temperature induced denaturation of double stranded DNA.
- The amplified fragment can be used to ligate with a vector for further cloning.
- **Steps in PCR technique :**
  - **(a) Denaturation:** Here, the double stranded DNA is denatured using high temperature to form single strand which act as a template for DNA synthesis.
  - **(b) Annealing of Primers:** Two sets of primers are annealed or hybridized at low temperature using suitable enzymes based on the length and the sequence of the primers.
  - **(c) Extension of Primers:** The primers are extended by adding nucleotides complementary to the template by Taq DNA polymerase.

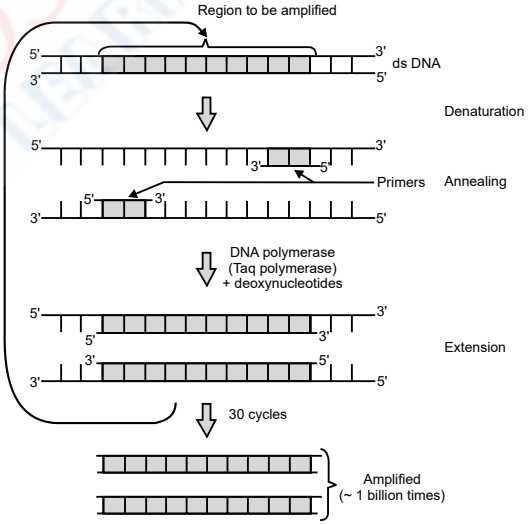

Fig. 3.5: Steps in PCR technique

D. Insertion of Recombinant DNA into the Host Cell/Organism

- There are several methods of introducing the ligated DNA into recipient cells.
- Recipient cells after making them competent, take up DNA present in its surrounding.

- If a recombinant DNA bearing ampicillin resistant gene, a selectable marker gene is transferred into *E. coli* cells, then the host cells become ampicillin resistant cells.
- If the transformed cells are spread on agar plates containing ampicillin, only transformants will grow while the untransformed recipient cells will die.

E. Obtaining the Foreign Gene Product

- The ultimate aim of recombinant DNA technology is to produce a desirable protein.
- For this, there is a need for the recombinant DNA to be expressed.
- The foreign gene get suppressed under appropriate conditions.
- If a protein encoding gene is expressed in a heterologous host, it is called a recombinant protein.
- The cells with foreign genes may be grown on a small scale in the laboratory.
- The cultures may be used to extract the desired protein and purify it by using different separation techniques.
- The cells can also be multiplied in a continuous culture system.
- In continuous culture system, the used medium is drained out from one side while fresh medium is added from the other.
- It maintains the cells more physiologically active and so produces a larger biomass leading to higher yields of desired protein.
- To produce large quantities of desired products, the bioreactors are used.
- Bioreactors are the vessels in which raw materials are biologically converted into specific products, enzymes etc., using microbial plant, animal or human cells.
- A bioreactor provides the optimal growth conditions such as temperature, pH, substrate, salts, vitamins, oxygen to obtain the desired product.
- The most commonly used bioreactors are of stirring type.

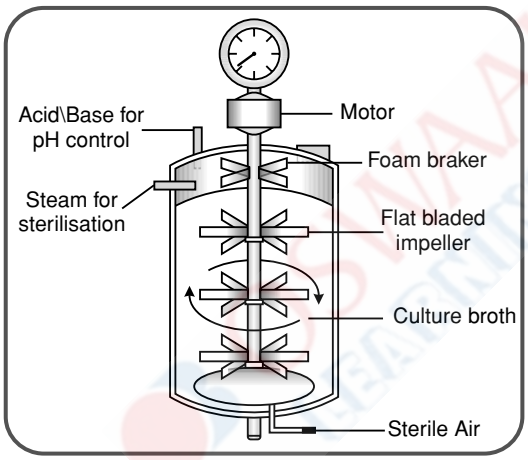

Fig. 3.6: Simple stirred-tank bioreactor

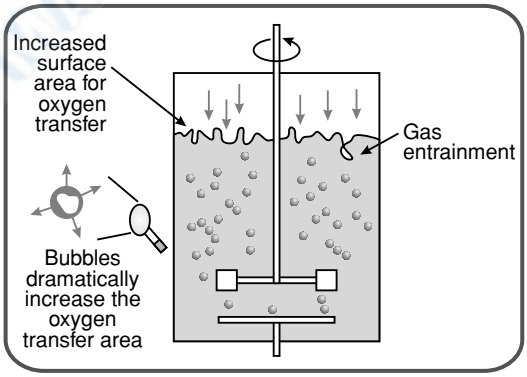

Fig. 3.7: Sparged stirred tank bioreactor

- **Stirred-Tank Reactor:** A stirred-tank reactor is cylindrical or with a curved base to facilitate the mixing of the reactor contents with available oxygen.
- Alternatively, air can be bubbled through the reactor.
- The bioreactor has :
  - **(a)** An agitator system
  - **(b)** An oxygen delivery system
  - **(c)** A foam control system
  - **(d)** A temperature control system
  - **(e)** pH control system
  - **(f)** Sampling ports, for periodic withdrawal of the culture.

F. Downstream Processing

- It is a series of processes such as separation and purification of products after the biosynthetic stage.
- The product is formulated with suitable preservatives.
- Such formulation undergoes thorough clinical trials as in case of drugs.

- Strict quality control testing for each product is also required.
- The downstream processing and quality control testing vary from product to product.

Know the Terms

- **PCR:** Polymerase Chain Reaction.
- **Bioreactors:** Bioreactors are vessels in which raw materials are biologically converted into specific products, enzymes, etc., using microbial plants, animal or human cells.
- **Selectable Marker:** The gene encoding desirable information useful in identifying and eliminating non-transformants and selectively permitting the growth of the transformants is called selectable marker.

❑❑

Chapter-4 : Biotechnology And Its Applications

TOPIC-1

Application of Biotechnology in the Field of Agriculture and Medicine

Revision Notes

- Biotechnology deals with industrial scale production of bio-pharmaceuticals and biologicals using genetically modified microbes, fungi, plants and animals.
- Biotechnology has a wide range application in medicine such as biopharmaceuticals, therapeutics, and diagnostics and in agriculture such as genetically modified crops for agriculture, processed food, bioremediation, waste water treatment and energy production.
- **Biotechnology has three critical research areas :**
  - **(a)** Providing the best catalyst in the form of improved organism usually a microbe or pure enzyme.
  - **(b)** Creating optimal conditions through engineering for a catalyst to act, and
  - **(c)** Downstream processing technologies to purify the protein/organic compound.

APPLICATIONS OF BIOTECHNOLOGY IN AGRICULTURE

- **There are three options for increasing food production namely,**
  - **(a)** Agro-chemical based agriculture.
  - **(b)** Organic agriculture.
  - **(c)** Genetically engineered crop-based agriculture.
- **The Green Revolution has increased the yield of crops due to :**
  - **(a)** Use of improved crop varieties.
  - **(b)** Use of agrochemicals such as fertilizers and pesticides.
  - (c) Use of better management practices.
- However, further increase in the yield with existing varieties of crops is not possible using conventional methods of breeding.
- Also, the agrochemicals cause soil and water pollution and are expensive for the farmers.
- In order to overcome these problems, genetically modified organisms provide the solution.

Genetically Modified Organisms (GMO) or Transgenic Organisms

- These are the plants, bacteria, fungi & animals whose genes are altered by manipulation.
- **Advantages of Genetic Modification in Plants**
  - **(a)** It makes crops more tolerant to abiotic stresses (cold, drought, salt, heat, etc).
  - **(b)** Pest-resistant crops reduce the use of chemical pesticides.
  - **(c)** It helps to reduce post-harvest losses.

(d) It increases efficiency of mineral usage by plants, thereby preventing early exhaustion of fertility of soil.

(e) It enhances nutritional value of food. e.g., Vitamin 'A' enriched rice.

(f) GM is used to create plants to supply alternative resources to industries, in the form of starch, fuels and pharmaceuticals.

Production of Pest Resistant Plants

- Pest resistant plants decrease the amount of pesticides used.
- Bt toxin is produced by a bacterium called *Bacillus thuringiensis*.
- Bt toxin gene has been cloned from bacteria and been expressed in plants to provide resistance to insects, thus in effects producing a bio-pesticide without the need for insecticides.
- Examples - Bt cotton, Bt corn, rice, tomato, potato and soyabean etc.

(a) Bt Cotton

- Some strains of *Bacillus thuringiensis* have proteins that kill insects like coleopterans (beetles), lepidopterans (tobacco budworm, armyworm) & dipterans (flies, mosquitoes).
- *B. thuringiensis* forms a toxic insecticidal protein (Bt toxin) crystals during a particular phase of their growth.
- It does not kill the *Bacillus* as it exists as inactive protoxins.
- When an insect ingest the inactive toxin, it is converted into active toxin due to the alkaline pH of the gut which solubilise the crystals.
- The activated toxin binds to the surface of midgut epithelial cells and creates pores that causes cell swelling, lysis and ultimately the death of the insect.
- Bt toxin genes were isolated from *B. thuringiensis* and incorporated into crop plants such as cotton.
- Most Bt toxins are insect-group specific.
- The toxin is coded by a gene named cry.

  e.g., The proteins encoded by the genes (cryIAc) and (cryIIAb) control the cotton bollworms, that of (cryIAb) controls corn borer.

(b) Nematode Resistance in Tobacco Plants

- A nematode *Meloidegyne incognita* infects the roots of tobacco plants and causes a great reduction in yield.
- RNA interference (RNAi) strategy is used to prevent this infestation.
- RNAi is a method of cellular defense in all eukaryotic organisms.
- It prevents translation of a specific mRNA (silencing) due to a complementary dsRNA molecule that binds to the mRNA.
- The source of this complementary RNA is from an infection by RNA virus or mobile genetic elements (transposons) that replicate via an RNA intermediate.
- Using *Agrobacterium* vectors, nematode-specific genes (DNA) were introduced into the host plant.
- It produced both sense and anti-sense RNA in the host cells.
- These two RNA's being complementary to each other form a double stranded RNA (dsRNA) that initiates RNAi, thereby silencing the specific mRNA of nematode.
- The parasite cannot survive in a transgenic host expressing specific interfering RNA.
- The transgenic plant therefore got itself protected from the parasite.

APPLICATION IN MEDICINE

- The recombinant DNA technology helps for the mass production of safe and more effective therapeutic drugs.
- The recombinant therapeutics does not induce unwanted immunological responses as in case of similar products isolated from non-human sources.
- At present, there are about 30 recombinant therapeutics that have been approved for human-use the world over.

Genetically Engineered Insulin

- Management of adult-onset diabetes is possible by taking insulin at regular time intervals.
- Now, it is possible to produce human insulin using bacteria.
- Insulin extracted from the pancreas of animals such as cattle and pigs causes allergy or other types of reactions to the foreign protein.
- Insulin consists of two short polypeptide chains namely, chain A and chain B that are linked together by disulphide bridges.

- In mammals, insulin is synthesized as a pro-hormone.
- The pro-hormone needs processing before it becomes a fully matured and functional hormone.
- The pro-hormone contains an extra stretch called the C-peptide, which is removed during maturation into insulin.
- In 1983, Eli Lilly an American company prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of *E. coli* to produce insulin chains.
- These chains were produced separately, extracted and combined by creating disulphide bonds to form human insulin.

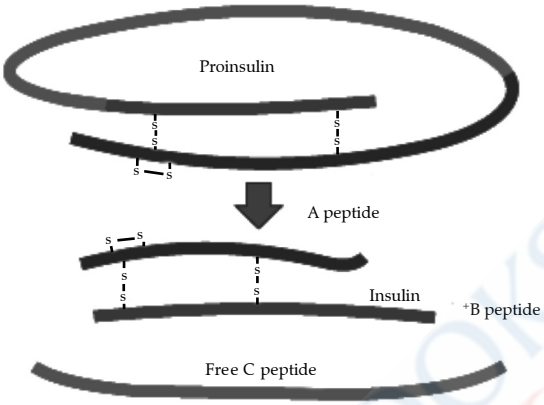

Fig. 4.1: Maturation of pro-insulin into insulin

Gene Therapy

- Gene therapy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/ embryo.
- Here, genes are inserted into a person's cells and tissues to treat a hereditary disease.
- Correction of a genetic defect involves delivery of a normal gene into the individual or embryo to take over the function and compensate for the non-functional gene.
- First clinical gene therapy was given in 1990 to a 4-year old girl with adenosine deaminase (ADA) deficiency.
- The disorder is caused due to the deletion of the gene for adenosine deaminase, the enzyme crucial for the immune system to function.
- This can be cured by bone marrow transplantation or by enzyme replacement therapy where injection of functional ADA is done.
- However, these approaches are not completely curative.
- In gene therapy, lymphocytes from the patient's blood are grown in a culture.
- A functional ADA cDNA, using a retroviral vector is introduced into these lymphocytes.
- Then, they are returned to the patient.
- This should be periodically repeated as these cells are not immortal.
- However, if the ADA gene from marrow cells is introduced into cells at early embryonic stages, it could be a permanent cure.

MOLECULAR DIAGNOSIS

- Recombinant DNA technology, PCR and Enzyme Linked Immuno-sorbent Assay (ELISA) are some of the techniques for early diagnosis.
- Presence of a pathogen is suspected only when the pathogen produces a disease symptom.
- By this time, the concentration of pathogen becomes very high in the body.
- However, very low concentration of a bacteria or virus can be detected by amplification of their nucleic acid by PCR.
- PCR is used to detect HIV in suspected AIDS patients.
- It is also used to detect mutations in genes in suspected cancer patients.
- It is a powerful technique to identify many genetic disorders.
- A single stranded DNA or RNA, tagged with a radioactive molecule (probe) is allowed to hybridise to its complementary DNA in a clone of cells followed by detection using autoradiography.

- The clone having the mutated gene will hence not appear on the photographic film, because the probe will not have complementarity with the mutated gene.
- ELISA is based on the principle of antigen-antibody interaction.
- Infection by pathogen can be detected by the presence of antigens (proteins, glycoproteins, etc.) or by detecting the antibodies synthesized against the pathogen.
- **Stem cells:** Stem cells provide new cells for the body as it grows, and replace specialised cells that are damaged or lost. Example includes embryonic cells.
- **They have two unique properties:**
  (a) They can divide over and over again to produce new cells.
  (b) As they divide, they can change into the other types of cell that make up the body.

Uses of stem cells:

- **Research:** To help us understand the basic biology of how living things work and what happens in different types of cell during disease.
- **Therapy:** To replace lost or damaged cells that our bodies can't replace naturally.
- **Types of stem cells:** Embryonic stem cells, Tissue-specific stem cells, Induced pluripotent stem cells and Mesenchymal stem cells.
- Stem cell technology is a rapidly developing field that combines the efforts of cell biologists, geneticists, and clinicians and offers hope of effective treatment for a variety of malignant and non-malignant diseases.

Know the Terms

- **ADA:** Adenosine Deaminase. This enzyme is crucial for the function of the immune system.
- **GMO:** Genetically Modified Organisms. These are organisms whose genes have been altered.
- **Gene Therapy:** It is a method that allows correction of a gene defect.
- **Probe:** Hybridization probe is a fragment of DNA or RNA of variable length (usually 100-1000 bases long) which is radioactively labeled then it can be used in DNA or RNA samples to detect the presence of nucleotide sequences (the DNA target) that are complementary to sequence in the probe.
- **PCR:** Polymerase Chain Reaction.
- **ELISA:** Enzyme Linked Immuno-Sorbet Assay.
- **Vaccines:** It is a liquid containing dead or attenuated pathogen or it is an antigen that provides temporary or permanent immunity to a disease.
- **DNA vaccines:** DNA vaccines use one or more isolated genes of a pathogen, incorporate these genes into 'plasmids' and inject them into the muscle or deliver them into human body.
- **SCID:** Severe Combined Immuno Deficiency. It is caused by a defect in the gene for the enzyme adenosine deaminase (ADA).

Mnemonics

Concept: Vectors : Affecting plants
Mnemonics: Aeroplane **T**ruck **B**us **T**rain : **T**ransport **C**onveyance
Interpretation: **A**grobacterium **T**umefaciens : **T**obacco **B**acillus **t**huringiensis : **C**otton

TOPIC-2
Transgenic Animals and Ethical Issues

Revision Notes

TRANSGENIC ANIMALS

- These are the animals whose genome has been altered by introduction of an extra (foreign) gene by manipulation.
- **Examples :** Transgenic rats, rabbits, pigs, sheep, cows and fish.
- Over 95% of all existing transgenic animals are mice.

Transgenic Cow

- In 1997, Rosie (first transgenic cow) produced human protein-enriched milk (2.4 gm per litre).
- It contains the human α-lactalbumin, which is nutritionally more balanced product for human babies than natural cow-milk.

Advantages of Transgenic Animals

(a) To study Normal Physiology and Development :

- Transgenic animals are used to study regulation of genes and their effect in normal body functions and its development.

  e.g., study of complex factors such as insulin-like growth factor.
- Genes from other species that alter the formation of this factor are introduced and the biological effects are studied.
- This gives information about the biological role of the factor in the body.

(b) To study Various Diseases :

- Transgenic models help investigate new treatments for human diseases.
- **Examples :** Transgenic models for many human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's.

(c) To produce useful Biological Products :

- Some medicines contain biological products, but they are often expensive.
- Transgenic animals are used to produce useful biological products by introducing genes which codes for a particular product.
- **Examples :** Human protein (α-1-antitrypsin) is used to treat emphysema, phenylketonuria (PKU) and cystic fibrosis, etc.

(d) Vaccine Safety :

- Transgenic mice are used in testing the safety of the polio vaccine used on humans.
- If it is found to be reliable, they can replace the use of monkeys to test the safety of batches of the vaccine.

(e) Chemical Safety Testing (Toxicity Testing)

- Transgenic animals are made to carry genes which make them more sensitive to toxic substances than non-transgenic animals.
- Then they are exposed to the toxic substances and the effects studied.
- It gives immediate results.

ETHICAL ISSUES

- Genetic modification may cause unpredictable results when such organisms are introduced into the ecosystem.
- Therefore, Indian Government has set up organizations like GEAC (Genetic Engineering Approval Committee), which make decisions about the validity of GM research and the safety of GM-organisms for public services.
- Certain companies have got patents for products and technologies that make use of the genetic materials, plants etc that have been identified, developed and used by farmers and indigenous people of a specific region/country.
- E.g.-Basmati rice, herbal medicines like turmeric, neem etc.

Basmati Rice

- It has unique aroma and flavour.
- India has 27 documented varieties of Basmati.
- In 1997, an American company got patent rights on Basmati rice through the US Patent and Trademark Office. This allowed the company to sell a'new' variety of Basmati.
- This had actually been derived from Indian farmer's varieties.
- Indian Basmati was crossed with semi-dwarf varieties and claimed as a novelty.
- Other people selling Basmati rice could be restricted by the patent.

Biopiracy

- It refers to the use of bio-resources by multinational companies and other organizations without proper authorization from the countries and people concerned without compensatory payment.
- Most of the industrialized nations are poor in biodiversity and traditional knowledge.

- The developing and the underdeveloped world have rich biodiversity and traditional knowledge related to bio-resources.
- It has to develop laws to prevent unauthorized exploitation of bio-resources and traditional knowledge.
- Indian Parliament has cleared the second amendment of the Indian Patents Bill that takes such issues into consideration, including patent terms, emergency provisions and research and development initiative.

Know the Terms

- **Biopatent :** A patent is the right granted by a government to an inventor to prevent others from commercially using his invention. When patents are granted for biological entities and for products derived from them, these patents are called biopatents.
- **Biopiracy :** Some organizations and multinational companies exploit and patent biological resources or bioresources of other nations, without proper authorization from the countries concerned without any payment. This is called biopiracy.
- **GEAC :** Genetic Engineering Approval Committee. It makes decision regarding the validity of GM research and safety of introducing GM-organisms for public services.
- **Transgenic animals :** Animals that have their DNA manipulated to possess and express an extra or a foreign gene are known as transgenic animals.

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UNIT-5 : ECOLOGY AND ENVIRONMENT

Chapter-5 : Organisms and Populations

TOPIC-1

Organisms and Its Environment

Revision Notes

ECOLOGY

- Ecology refers to the interactions among organisms and its physical or abiotic environment.
- Ecology is basically concerned with four levels of biological organisation-organisms, populations, communities and biomes.
- **Levels of biological organizations are:** Macromolecules → cells → tissues → organs → organisms → population → communities → ecosystem → biomes.

Mnemonics

Concept: Ecological Hierarchy

Mnemonics: Idiot! Please Carry Everyone's Biology Books

Interpretation:

I - Individual	**P** - Population	**C** - Community
E - Ecosystem	**B** - Biome	**B** - Biosphere

ORGANISMS AND ITS ENVIRONMENT

- At organism level, ecology makes us understand about the adaptations of different organisms to their environment in terms of survival and reproduction.
- The rotation of Earth around the sun and the tilt of its axis cause annual variation in the intensity and duration of temperature leading to different seasons.

- These variations together with annual variation in precipitation (rain and snow) results in the formation of major biomes such as desert, rain forest and tundra.
- Regional and local variations within each biome result in the formation of variety of habitats.

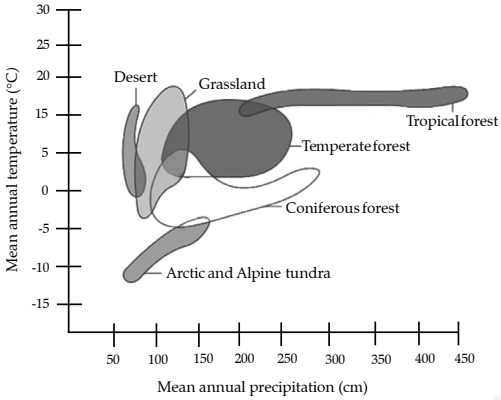


Fig . 5.1: Biome distribution with respect to annual temperature and precipitation.

Major Abiotic Factors

(a) Temperature

- The average temperature on the land varies seasonally, decreases from the equator towards the poles and from plains to the mountain tops.
- It ranges from sub-zero levels in polar areas and high altitudes to > 50°C in tropical deserts in summer.
- There are unique habitats such as thermal springs and deep-sea hydrothermal vents where the average temperature exceeds 100^0C.
- Mango trees do not and cannot grow in temperate countries like Canada and Germany, snow leopards are not found in Kerala forests and tuna fish are not seen beyond tropical latitudes in the ocean.
- The temperature affects the kinetics of enzymes, basal metabolism, activity and other physiological functions.
- Organisms that can tolerate and survive in a wide range of temperature are called Eurythermal organisms.
- Organisms that cannot tolerate and survive in a wide range of temperature are called Stenothermal organisms.
- The thermal tolerance of different species varies with their geographical distribution.

(b) Water

- The productivity and distribution of plants depend on the water.
- For aquatic organisms, the quality (chemical composition, pH) of water, the salt concentration (salinity in parts per thousand) are important.
- The salt concentration is less than 5% in inland waters, 30 – 35% in the sea and is greater than 100% in hyper saline lagoons.
- Organisms that can tolerate a wide range of salinity are called Euryhaline.
- Organisms that cannot tolerate a wide range of salinity are called Stenohaline.
- Many freshwater animals cannot live for long in sea water and vice-versa because of osmotic pressure problems.

(c) Light

- Plants prepare their own food with the help of sunlight, carbon dioxide, water, chlorophyll by the process called photosynthesis.
- Sunlight is available as a source of energy.
- Small plants such as herbs and shrubs growing in forests are adapted to photosynthesis optimally under very low light conditions because they are shadowed by tall trees.
- Plants depend on sunlight for flowering.
- Many animals use the diurnal and seasonal variations in light intensity and duration for timing their foraging, reproductive and migratory activities.
- Deep in the oceans (>500 m), the environment is perpetually dark and its inhabitants are not aware of the existence of sun, a celestial source of energy.
- The UV component of the spectrum is harmful to many organisms while not all the colour components of the visible spectrum are available for marine plants living at different depths of the ocean.

(d) Soil

- The nature and the properties of soil in different places depend on the climate, weathering process and the development of the soil.
- The characteristics of soil such as composition, size and aggregation determine the percolation and water holding capacity of the soil.
- The characteristics of the soil with pH, mineral composition and topography determine the vegetation in an area.
- In the aquatic environment, the soil characteristics determine the type of benthic animals that can live there.

Responses to Abiotic Factors

- Many species would have evolved at a constant internal environment that allows all biochemical reactions and physiological functions to have maximum efficiency and enhancing the overall fitness of the species.
- The organisms should try to maintain the constancy of its internal environment (homeostasis) despite varying external environmental conditions.
- **The possibilities through which living organism cope with the abiotic situations are :**
  - **(a)** Regulate
  - **(b)** Conform
  - **(c)** Migrate
  - **(d)** Suspend

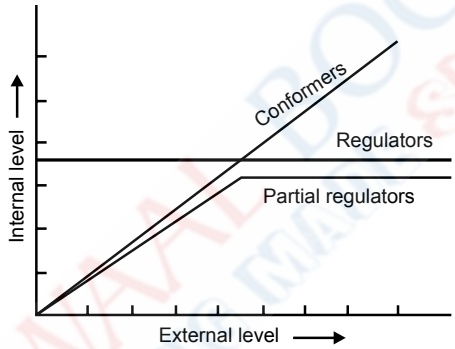


Fig. 5.2: Diagrammatic representation of organismic response

(a) Regulate

- Some organisms maintain homeostasis by physiological or behavioural means ensuring constant osmotic concentrations, body temperature (osmo and thermoregulation) etc.
- Birds, mammals and few lower vertebrates and invertebrates are capable of osmo and thermoregulation.
- **Examples** – Success of mammals in Antarctica and in Sahara Desert.
- A constant body temperature of an human being is 37°C.

(b) Conform

- Nearly 99% animals and almost all plants cannot maintain a constant internal temperature. Their body temperature changes with the ambient temperature.
- In aquatic animals and plants, the osmotic concentration of the body fluid changes with that of ambient water osmotic concentration. These animals and plants are called conformers.
- Heat loss or gain depends on the surface area.
- Larger the area, the body lose heat very fast when it is cold outside; they tend to spend more energy to produce heat in their body. So small animals with a larger surface area relative to their volume are rarely found in Polar regions.
- Later some species have evolved the ability to regulate a limited range of environmental conditions beyond which they are conformers.
- If stressful external conditions are seen for a short duration, the organisms undergo migration or get suspended.

(c) Migration

- The organism move away temporarily to more hospitable habitat and return after the stressful period is over.
- Particularly birds, during winter undergo long distance migrations.
- **Examples –** Keoladeo National Park at Bharatpur in Rajasthan host thousands of migratory birds from Siberia.

(d) Suspend

- Bacteria, fungi and other lower plants form thick walled spores during unfavourable conditions to survive which later during favourable conditions germinate to form new plants.
- In higher plants, seeds and other vegetative reproductive structures help to overcome the period of stress by reducing their metabolic activity and undergoing a period of 'dormancy'.
- **Examples –** Bears undergo hibernation during winters. Snails and fish undergo aestivation to avoid summer, related problems heat and desiccation.
- Zooplankton species in lakes and ponds undergo diapause, a stage of suspended development.

ADAPTATIONS

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

Adaptations of Kangaroo Rat in North American Desert

- In absence of an external source of water, the Kangaroo rat in North American deserts meet their water requirement through internal fat oxidation in which the water is the by-product and also through concentrating its urine to minimal volume of water as excretory products.

Adaptations of Desert Plants

- Many desert plants have thick cuticle on their leaf surfaces and stomata to minimize water loss through transpiration.
- CAM, a special photosynthetic pathway in them enables their stomata to remain closed during day time.
- Some plants like *Opuntia* have spines which are modified leaves and the function of the leaf is taken over by the flattened stem, which is green in colour.

Adaptations of Mammals

- **Allen's Rule –** Mammals from colder region have shorter ears and limbs to reduce the heat loss.
- Polar aquatic mammals have a thick layer of fat or blubber below their skin that acts as an insulator to reduce the heat loss. **Example –** Seal.

Physiological and Biochemical Adaptations

- Some organisms adapt physiologically to respond to a stressful situation.
- **Examples:** Humans at high altitudes > 3500m near Rohtang Pass, near Manali and Mansarovar, in China occupied Tibet experiences altitude sickness due to low atmospheric pressure which results in nausea, fatigue and heart palpitations. But soon get acclimatized and stop experiencing altitude sickness.
- The process of adaptation is that the body compensates low oxygen by increasing RBC production and decreasing the binding affinity of haemoglobin and by increasing breathing rate.
- Tribes living in high altitude of Himalayas have higher RBC count than the people living in the plains.
- Microbes like archaebacteria can live in hot springs and deep sea hydrothermal vents.
- Many fish live in Antarctic region where the temperature is always below zero.
- Many marine invertebrates and fishes live at great depths in the ocean where the pressure is >100 times the normal atmospheric pressure.

Behavioural Adaptations

- Desert lizards lack the physiological ability to deal with the high temperatures but manage to keep their body temperature constant by absorbing heat from the sun when their body temperature drops below the comfort zone and then come to shade when the ambient temperature starts increasing.
- Some species burrow into the soil to hide and escape from the above ground heat.

Know the Terms

- **Ecology:** The branch of biology that deals with the study of interaction among organisms and between the organism and its physical (abiotic) environment.
- **Adaptation:** It is any morphological, physiological or behavioural attributes of an organism that enables it to survive and reproduce in its habitat.
- **Hibernation:** A process by which the animals avoid the stress and become inactive during winter.

- **Diapause:** It refers to a stage of suspended development shown by many zooplankton species in fresh water bodies.
- **Conformers:** The animals and plants whose internal environment change with the change in external environment.
- **Aestivation:** It is the process of spending the dry hot periods or summers in an inactive or dormant state to escape in time.
- **Ecological Niche:** It refers to the range of conditions an organism can tolerate, the resources it utilizes and its distinct functional role in the ecological system.
- **Eurythermal animals:** The animals which can tolerate a wide range of temperature and are geographically widely distributed.
- **Ectotherms:** Animals whose body temperature changes and matches with that of the environment in which they are living.
- **Endotherms:** Animals whose body temperature is maintained relatively constant by physiological regulations.
- **Euryhaline animals:** The animals which can tolerate a wide range of salinity.
- **Habitat:** The place where an organism lives is called its habitat.
- **Homeostasis:** It refers to the maintenance of a steady internal environment by organisms.
- **Hibernation:** It is the process of spending the winters in an inactive or dormant state to escape in time.
- **Stenothermal animals:** The animals which can tolerate only a very narrow range of temperature and are restricted in distribution.
- **Stenohaline animals:** The animals which can tolerate a very narrow range of salinity.
- **Ecotypes:** Ecotypes are local populations of a species that are genetically adapted to a particular variations of environment.
- **Phenotypic plasticity:** Variations produced amongst individuals of a species due to influence of local conditions of a habitat are collectively called phenotypic plasticity.
- **Climate:** Average weather of an area.
- **Weather:** The short term properties of atmosphere at a given place and time.
- **Microclimate:** It represents climatic conditions at a local scale in area of limited size.

TOPIC-2
Population and Its Attributes

Revision Notes

POPULATION

- A population is a group of individuals of same species that live in a given geographical area, share or compete for similar resources and potentially reproduce.

  Example - All the cormorants in a wetland, rats in an abandoned dwelling, teakwood trees in a forest tract, bacteria in a culture plate and lotus plants in a pond etc.
- Population ecology is an important area of ecology as it links ecology to population genetics and evolution.

POPULATION ATTRIBUTES

(a) Birth Rate and Death Rate

- An individual may have deaths and births, but a population has birth and death rates.
- In a population these rates refer to per capita births and deaths respectively.
  - **Calculation of Birth Rate**
    - Consider in a pond there are 20 lotus plants last year and through reproduction 8 new plants are added.
    - Hence, the current population = 28
    - The birth rate = 8/20 = 0.4 offspring per lotus per year.
  - **Calculation of Death Rate**
    - Consider 4 individuals in a laboratory population of 40 fruit flies died during a week.
    - Hence, the death rate = 4/40 = 0.1 individuals per fruit fly per week.

(b) Sex Ratio

- Another characteristic of a population is sex ratio where an individual is either a male or female but a population has a sex ratio of 60% females and 40% males.

(c) Age Pyramid

- When a population at any given time is plotted against the age distribution, the resulting structure is called an age pyramid.
- For human population, the age pyramids show age distribution of males and females in a combined diagram.
- The shape of the pyramids shows the growth of the population whether it is growing, stable or declining.

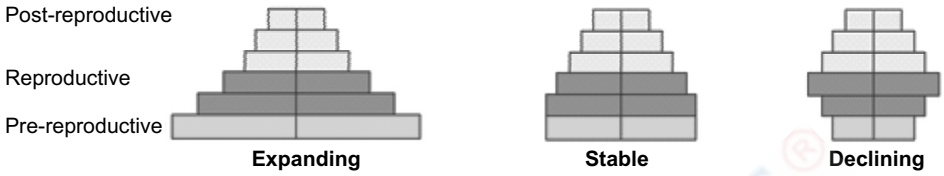


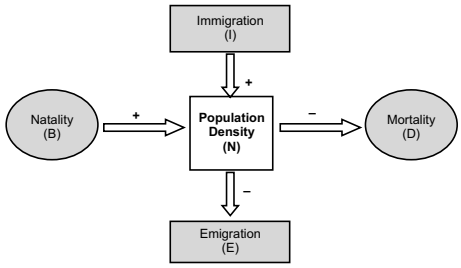
Fig. 5.3: Representation of age pyramids for human population

(d) Population Size or Population Density (N)

- It is the number of individuals of a species per unit area or volume.
- The size of the population inform us about its status in the habitat, ecological processes in a population, outcome of competition with another species, the impact of predator or the effect of a pesticide.
- The size could be as low as <10 (Siberian cranes at Bharatpur wetlands) or into millions (*Chlamydomonas* in a pond).
- Population size is technically called as population density (N).
- In some cases, population size is measured in percentage cover or biomass.

  Example - Consider in an area, 200 *Parthenium* plants and a single huge banyan tree are seen. Here the per cent cover or biomass is a measure of the population size to show the importance of banyan tree.
- Total number is a difficult measure for a huge population.
- For ecological investigations, relative density is taken than the absolute population density.

  Example - The number of fish caught per trap indicates its total population density in the lake.
- Population size can be estimated indirectly, for example, the tiger census in our national parks and tiger reserves is based on pug marks and faecal pellets.
- The population size changes in time, depending on various factors like food availability, predation, pressure and weather.
- Changes in population density give some idea about the population whether it is flourishing or declining.
- **Factors Affecting Population Density**
  - **(a) Natality (B):** It is the number of births in a population during a given period.
  - **(b) Mortality (D):** It is the number of deaths in a population during a given period.
  - **(c) Immigration (I):** It is the number of individuals of the same species that have come into the habitat from elsewhere during a given time period.
  - **(d) Emigration (E):** It is the number of individuals of the population who left the habitat and gone elsewhere during a given time period.



- **Differences between Natality Rate and Mortality Rate :**

S.No.	Natality Rate	Mortality Rate
1.	Addition of new individuals due to birth, hatching or germination or division.	It is number of deaths per unit population per unit time, e.g., per one thousand individuals per year in humans.
2.	It adds new members to the population. As a result, it increases the size of population.	It decreases the size of the population.

- If N is the population density at time *t*, B is number of births, D is number of deaths, E is emigrants and I is immigrants then its density at time *t* +1 will be: $N_{t+1} = N_t + [(B + I) – (D + E)]$
- The above equation indicates that population density increases if B + I is more than D + E otherwise it will decrease.
- Under normal conditions, births and deaths are important factors influencing population density.
- The other two factors have importance only under special conditions.
- For example, if a new habitat is just being colonized, immigration may be more significant to population growth than birth rates.

Growth Model

- There are two growth models namely, exponential growth model and logistic growth model.

(a) Exponential Growth

- Resource availability (food & space) is essential for the unimpeded population growth.
- If resources are unlimited, each species shows its full innate potential to grow in number.
- Then, the population grows in an exponential or geometric fashion.
- If in a population of size N, the birth rates (per capita births) are represented as b and death rates (per capita deaths) as d, then the increase or decrease in N during a unit time period (t), (dN/dt) will be :

  $dN/dt = (b – d) \times N$

  Let (b–d) = r, then

  $dN/dt = rN$

  The r ('intrinsic rate of natural increase') is an important parameter for assessing impacts of any biotic or abiotic factor on population growth.

  The r value for the Norway rat = 0.015

  The r value for the flour beetle = 0.12

  The r value for human population in India (1981) = 0.0205

- The integral form of the exponential growth equation is : $N_t = N_o e^{rt}$

  Where,

  N_t = Population density after time t, N_0 = Population density at time zero, r = Intrinsic rate of natural increase, e = the base of natural logarithms (2.71828)

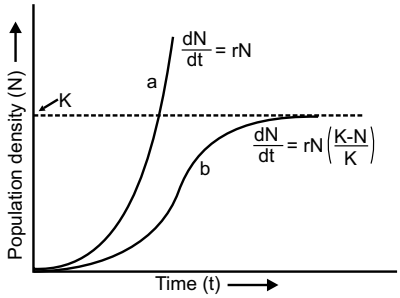
(b) Logistic Growth

- There is no population in nature having unlimited resources for exponential growth.
- This leads to competition between individuals for limited resources.
- Eventually, the 'fittest' individuals survive and reproduce.
- In nature, a given habitat has enough resources to support a maximum possible number, beyond which no further growth is possible. It is called carrying capacity (K).
- A population 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. This type of population growth is called Verhulst-Pearl Logistic Growth.
- **Verhulst-Pearl Logistic Growth**

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

- Where, N is the population density at time t, r is the intrinsic rate of natural increase, K is the carrying capacity.

- Since resources for growth for most animal populations are finite, the logistic growth model is more realistic one.
- **Population Growth Curves :**



- The curve 'a' indicates exponential growth (J-shaped curve) while the curve 'b' indicates logistic growth (Sigmoid curve).

Life History Variation

- Populations evolve to maximise their reproductive fitness or Darwinian fitness (high r value). Under a particular set of selection pressures, organisms evolve towards the most efficient reproductive strategy.
- Some organisms breed only once in their lifetime (Pacific salmon fish, bamboo) while others breed many times (most birds and mammals).
- Some produce a large number of small-sized offspring (oysters, pelagic fishes) while others produce a small number of large-sized offspring (birds, mammals).
- The above facts indicate that life history traits of organisms have evolved due to limited abiotic and biotic components of the habitat.

POPULATION INTERACTIONS

- In nature, animals, plants and microbes interact in various ways to form a biological community.
- Interspecific interactions arise from the interaction of populations of two different species.
- **The interspecific interactions include,**
  - **(a) Mutualism :** Both the species are benefitted (+).
  - **(b) Competition :** Both the species are harmed (-)
  - **(c) Parasitism :** One species (parasite) is benefitted and other species (host) is harmed.
  - **(d) Predation :** One species (predator) is benefitted and other species (prey) is harmed.
  - **(e) Commensalism :** One species is benefitted and the other is neither benefitted nor harmed.
  - **(f) Amensalism :** One species is harmed and the other is unaffected.

Species A	Species B	Name of interaction
+	+	Mutualism
–	–	Competition
+	–	Predation
+	–	Parasitism
+	0	Commensalism
–	0	Amensalism

- In predation, parasitism and commensalisms, the interacting species live closely together.

A. Predation

- In a broad ecological context, all carnivores, herbivores etc., are predators.
- About 25 % of all insects are phytophagous.
- If a predator overexploits its prey, then the prey might become extinct.
- It results in the extinction of predator and so, predators in nature are 'prudent'.

Importance of Predators

(a) Predators keep prey populations under control. When certain exotic species are introduced into a geographical area, they spread fast due to the absence of its natural predators in the invaded land. **Example -** The prickly pear

cactus introduced into Australia in the early 1920's caused havoc by spreading. Finally, the invasive cactus was brought under control only after a cactus-feeding predator (a moth) was introduced into the country. Biological control methods are based on the ability of the predator to regulate prey population.

(b) Predators maintain species diversity in a community, by reducing the intensity of competition among competing prey species. **Example** - The starfish *Pisaster* is a predator in the rocky intertidal communities of the American Pacific Coast. In an experiment, when all the starfishes were removed from an enclosed intertidal area, more than 10 species of invertebrates became extinct within a year, due to interspecific competition.

Defenses of prey species to lessen impact of predation :

- Some insects & frogs are camouflaged (cryptically coloured) to avoid being detected by the predator.
- Some are poisonous and so avoided by the predators.
- The Monarch butterfly is highly distasteful to its predator (Bird) due to a special chemical in its body.
- This chemical is acquired during its caterpillar stage by feeding on a poisonous weed.
- Thorns (*Acacia*, *Cactus* etc.) are the most common morphological means of defence of plants.
- Many plants produce chemicals that make the herbivore sick, inhibit feeding or digestion, disrupt its reproduction or kill it.

  Example - *Calotropis* (a weed growing in abandoned fields) produce highly poisonous cardiac glycosides.
- Therefore cattle or goats do not eat it. Nicotine, caffeine quinine, strychnine, opium, etc., are defenses against grazers and browsers.

B. Competition

- Interspecific competition is a potent force in organic evolution.
- Competition is a process in which fitness of one species (measured as 'r' value) is significantly lower in presence of another species.
- Competition occurs when closely related species compete for the same limited resources.
- Unrelated species can also compete for the resource.

  Example - Flamingoes & fishes in some shallow South American lakes compete for zooplankton.
- Competition occurs in abundant resources also.

  Example - In interference competition, the feeding efficiency of one species is reduced due to the interfering and inhibitory presence of other species, even if resources are abundant.

Evidences for Competition

- The Abingdon tortoise in Galapagos Islands became extinct within a decade after goats were introduced on the island, due to greater browsing efficiency of the goats.

'Competitive release' :

- A species, restricted to a small geographical area (due to the presence of competitively superior species), expands its distributional range when the competing species is experimentally removed.
- Connell's field experiments showed that on the rocky sea coasts of Scotland, the larger & competitively superior barnacle *Balanus* dominates intertidal area, and excludes the smaller barnacle *Chthamalus* from that zone.

Gause's 'Competitive Exclusion Principle'

- It states that "two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior one will be eliminated eventually".
- This may be true in limited resources, but not otherwise.
- Species facing competition may evolve mechanisms that promote co-existence rather than exclusion.

  Example - (a) 'Resource partitioning'. If two species compete for the same resource, they could avoid competition by choosing different times for feeding or different foraging patterns.

  (b) MacArthur showed that five closely related species of warblers living on the same tree were able to avoid competition and co-exist due to behavioural differences in their foraging activities.

C. Parasitism

- Many parasites have evolved to be host-specific i.e., they can parasitize only a single species of host in such a way that both host and the parasite tend to co-evolve.
- If the host evolves special mechanisms for rejecting or resisting the parasite, the parasite has to evolve mechanisms to counteract and neutralize them, in order to be successful with the same host species.

- **Adaptations of parasites :**
  - **(a)** Loss of sense organs.
  - **(b)** Presence of adhesive organs or suckers to cling on to the host.
  - **(c)** Loss of digestive system, high reproductive capacity etc.
- Majority of the parasites harm the host.
- They may reduce the survival, population density, growth and reproduction of the host.
- They might render the host more vulnerable to predation by making it physically weak.
- Life cycles of parasites are often complex.

  Examples :
  - **(a)** Human liver fluke depends on two intermediate hosts (*i.e.*, a snail & a fish) to complete its life cycle.
  - **(b)** Malarial parasite needs mosquito to spread to other hosts.
- The parasites are classified into two types namely, ectoparasites and endoparasites.

  (a) Ectoparasites
  - Parasites that feed on the external surface of the host organism is known as ectoparasites.

    Example - Lice on humans and ticks on dogs. Many marine fish are infested with ectoparasitic copepods. *Cuscuta*, a parasitic plant that is commonly found growing on hedge plants, has lost its chlorophyll and leaves in the course of evolution.
  - It derives its nutrition from the host plant which it parasitizes.
  - The female mosquito is not considered a parasite, although it needs our blood for reproduction.

  (b) Endoparasites
  - Parasites that live inside the host body at different sites (liver, kidney, lungs, RBC etc.) are known as endoparasites.
  - The life cycles of endoparasites are more complex.
  - Their morphological & anatomical features are simplified while emphasizing their reproductive potential.

Brood Parasitism in Birds

- Here, the parasitic birds lay eggs in the nest of its host and lets the host incubate them.
- During the course of evolution, the eggs of the parasitic bird have evolved to resemble the host's egg in size and colour to reduce the chances of the host bird detecting the foreign eggs and removing them from the nest.

  Example - Brood parasitism between cuckoo and crow.

D. Commensalism

Examples

(a) Orchid (+) growing as epiphyte on a mango branch (0).

(b) Barnacles (+) growing on the back of a whale (0).

(c) Cattle egret (+) & grazing cattle (0). The egrets forage close to where the cattle are grazing. As the cattle move,the vegetation insects come out. Otherwise it is difficult for the egrets to find and catch the insects.

(d) Sea anemone (0) & clown fish (+). The fish gets protection from predators with the help of stinging tentacles of sea anemone. The anemone has no benefit.

E. Mutualism

- **Examples**
  - **(a) Lichen:** It is an intimate mutualistic relationship between a fungus & photosynthesizing algae or cyanobacteria.
  - **(b) Mycorrhizae:** These are associations between fungi & the roots of higher plants. The fungi help the plant in the absorption of essential nutrients from the soil while the plant provides the fungi with carbohydrates.

- **Example of mutualism between plant & animal through pollination and seed dispersion:**
  1. Many fig trees & wasps. The fig species is pollinated only by its 'partner' wasp species and no other species. The female wasp pollinates the fig inflorescence while searching for suitable egg-laying sites in fruits. The fig offers the wasp some developing seeds, as food for the wasp larvae.
  2. Orchids show diversity of floral patterns. They can attract the right pollinator insect (Bees & bumble bees) to ensure pollination. Not all orchids offer rewards.
  3. 'Sexual deceit' of *Ophrys* (The Mediterranean orchid). One petal of its flower resembles female bee in size, colour & markings. So, the male bee 'pseudocopulates' with the flower. The bee is dusted with pollen from the flower. When the same bee 'pseudocopulates' with another flower, it transfers the pollen. If the female bee's colour patterns change slightly during evolution, pollination success will be reduced unless the orchid flower co-evolves to maintain the resemblance of its petal to the female bee.

Mnemonics

Concept: Age Pyramids

Mnemonic: Three **B**ooks **U**sed: **E**ric **S**top **D**aydreaming

Interpretation:

Shape: **Population Growth**

Triangular shaped: **E**xpanding or **G**rowing | **B**ell shaped: **S**table | **U**rn shaped: **D**eclining

Concept: Population Interactions

Mnemonic: Competition **A**lways **M**uffle **P**olitics: **R**ivalry **H**as **F**abulous **B**enefits

Interpretation:

Type of interaction: Relationship

Competition: **R**ivalry

Antagonism: **H**armful

Mutualism: **F**avourable but not Obligatory

Proto-cooperation: **B**eneficial to both

Know the Terms

- **Carrying Capacity :** It is the maximum number of individuals of a population that can be sustained by a given habitat.
- **Emigration :** It refers to the number of individuals of the same species that have left the habitat during the time period under consideration.
- **Immigration :** It refers to the number of individuals of the same species that come into a habitat from elsewhere during the period under consideration.
- **Mortality :** It refers to the number of deaths in a population at a given period.
- **Natality :** It refers to the number of birth added to the initial density in a population during given period.
- **Population :** It refers to a group of individuals of the same species, occupying the same area at a given time.
- **Population Density :** It refers to the total number of individuals of a species present per unit area or volume at given time.
- **Population Growth Forms/Models :** It is the characteristic patterns of growth of a population with time.
- **Age pyramid :** It is a plot of the age distribution (percent individuals of a given age or age group) for a population.
- **Parasitism :** It is the mode of interaction between two species in which one species (parasite) depends on the other species (host) for food and shelter, in the process harming the host.
- **Mutualism :** It is an interaction that confers benefits to both interacting species.
- **Commensalism :** It is an interaction between two species in which one species is benefitted and the other is neither harmed nor benefitted.
- **Amensalism :** It is an interaction between two species in which one species is harmed and the other is neither benefitted nor harmed.

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Chapter-6 : Ecosystem

TOPIC-1

Ecosystem-Structure and Function, Productivity and Decomposition

Revision Notes

ECOSYSTEM

- An ecosystem is a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.
- Ecosystem varies greatly in size from a small pond to a large forest or a sea.
- Many ecologists regard the entire biosphere as a global ecosystem, as a composite of all local ecosystems on the Earth.

ECOSYSTEM: TYPES, STRUCTURE AND FUNCTION

- The ecosystem includes **biotic** and **abiotic** components.
- In an ecosystem, interaction of biotic and abiotic components takes place in a more integrated manner resulting in a physical structure that is characteristic for each type of ecosystem.
- Identification and enumeration of plant and animal species of an ecosystem gives its species composition.
- Vertical distribution of different species occupying different levels is called **stratification**.

  Example - Trees occupy top vertical strata (layer) of a forest, shrubs the second and herbs and grasses occupy the bottom layers.

Components of Ecosystem

- There are four basic components that function as a unit. These include,
  - **(a)** Productivity
  - **(b)** Decomposition
  - **(c)** Energy flow
  - **(d)** Nutrient cycling

Types of Ecosystem

- **(a) Terrestrial ecosystem:** Forest, grassland, desert etc.
- **(b) Aquatic ecosystem:** Pond, lake, wetland, river and estuary.
- **(c) Man-made ecosystem:** Crop fields and aquarium.

Aquatic Ecosystem: Pond

- A pond is a shallow, simple, self-sustainable water body that exhibits all basic components of an ecosystem.
- **Abiotic components in pond:** Water with dissolved inorganic and organic substances. The solar input, the cycle of temperature, day length and other climatic conditions regulate the rate of function of the entire pond.
- **Autotrophic components:** Phytoplankton, some algae and the floating, submerged and marginal plants.
- **Consumers (heterotrophs):** Zooplankton, free swimming and bottom dwelling forms.
- **Decomposers:** Fungi, bacteria and flagellates.
- **Pond performs all the functions of an ecosystem such as:**
  - **(a)** Conversion of inorganic into organic material with the help of the radiant energy of the sun by the autotrophs.
  - **(b)** Consumption of the autotrophs by heterotrophs.
  - **(c)** Decomposition and mineralization of the dead matter to release them back for reuse by the autotrophs.
- There is unidirectional movement of energy towards the higher trophic levels and its dissipation and loss as heat to the environment.

PRODUCTIVITY

- The rate of biomass production is called productivity. It is expressed in terms of $g^{-2}yr^{-1}$ or (kcal m^{-2}) yr^{-1}.

- It includes, primary productivity and secondary productivity.

(a) Primary Productivity

- It can be divided into gross primary productivity (GPP) and net primary productivity (NPP).
- GPP is the rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilized by plants in respiration.
- NPP is the available biomass for the consumption to heterotrophs (herbivores and decomposers).
- Gross primary productivity minus respiration losses (R) is the net primary productivity (NPP), *i.e.*, **NPP = GPP – R**
- Primary productivity depends on the plant species inhabiting a particular area and on various environmental factors.
- The primary productivity varies with different types of ecosystems.
- The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter.

  Despite occupying about 70 % of the surface, the productivity of the oceans is only 55 billion tons.
- **Primary productivity depends on the following:**
  - **(a)** The plant species inhabiting a particular area.
  - **(b)** Environmental factors.
  - **(c)** Availability of nutrients.
  - **(d)** Photosynthetic capacity of plants.

(b) Secondary Productivity: It is the rate of formation of new organic matter by consumers.

DECOMPOSITION

- It is the breakdown of complex organic matter by decomposers into inorganic substances like carbon dioxide, water and nutrients.
- The detritus is the raw material for decomposition. Detritus are dead plant remains such as leaves, bark, flowers and dead remains of animals, including *faecal matter.*
- The earthworm is referred to as the farmer's 'friend'. This is so because they help in the breakdown of complex organic matter as well as in loosening of the soil.
- **The steps involved in the decomposition process are :**
  - **(a) Fragmentation:** It is the breakdown of detritus into smaller particles by detritivores like earthworm.
  - **(b) Leaching:** Here, the water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.
  - **(c) Catabolism:** It is the degradation of detritus into simpler inorganic substances by bacterial and fungal enzymes.
  - **(d) Humification:** The degradation of detritus leads to accumulation of humus, a dark amorphous substance in soil. Humus is resistant to microbial action and so decomposes very slowly. Being colloidal in nature, it serves as a reservoir of nutrients.
  - **(e) Mineralization:** The humus gets degraded by some microbes and release inorganic nutrients. This process is called mineralization.
- **Factors influencing decomposition:**
  - **(a)** It is largely an oxygen-requiring process.
  - **(b)** It is controlled by chemical composition of detritus. Decomposition rate is slower if detritus is rich in lignin and chitin and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars.
  - **(c) Climatic factors like temperature and soil moisture:** Warm and moist environment favours decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in build up of organic materials.

Know the Terms

- **Biomass :** It refers to the amount of living or organic matter present in an organism.
- **Consumers :** All organisms which depend directly or indirectly on plants for their food are called consumers.
- **Decomposition :** It refers to the process in which the complex organic matter is broken down into simpler organic substances and ultimately into inorganic compounds.

- **Detritus :** It refers to the dead remains of plants and animals and also their faecal matter.
- **Detritivores :** It refers to those organisms which feed on the detritus and break it down into smaller particles.
- **Ecosystem :** An ecosystem is a functional unit of nature consisting of biotic and abiotic factors where the living organisms interact among themselves and also with their physical environment.
- **GPP :** Gross primary productivity is the rate of production of organic matter during photosynthesis.
- **NPP :** Net primary productivity is the available biomass for the consumption to heterotrophs.
- **Productivity :** It is the rate of production of biomass.
- **Primary Productivity :** It refers to the amount of biomass or organic matter produced per unit area over a time period by the plants during photosynthesis.
- **Stratification :** It refers to the vertical distribution of different species occupying different levels.
- **Secondary Productivity :** It refers to the rate of assimilation and formation of new organic matter by consumers.
- **Ecotone :** The transitional zone between two vegetation regions is called ecotone.
- **Canopy :** Part of a woodland or forest community that is formed by trees is called canopy.

TOPIC-2

Energy Flow, Ecological Pyramids, Ecological Succession and Nutrient Cycling

Revision Notes

ENERGY FLOW

- Sun is the only source of energy for all ecosystems except deep sea hydro-thermal ecosystem.
- Of the incident solar radiation, less than 50% of it is photosynthetically active radiation (PAR).
- Plants, photosynthetic and chemosynthetic bacteria (autotrophs), fix solar radiant energy to prepare food.
- Plants capture only 2-10% of the PAR to sustain the entire living world.
- Hence, it is very important to know how the solar energy captured by plants flows through different organisms of an ecosystem.
- Ecosystems obey second law of thermodynamics.
- They need a constant supply of energy to synthesize the molecules they require, to counteract the universal tendency toward increasing disorderliness.
- The energy flow begins with producers and ends with tertiary producers.

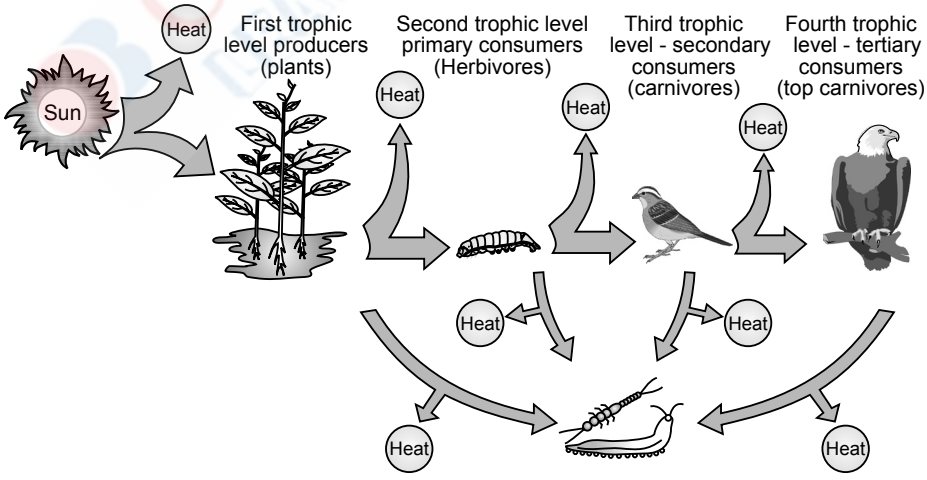

Fig. 6.1: Energy Flow Through Different Trophic Level

Producers (Autotrophs)

- All organisms are dependent for their food on producers (green plants), either directly or indirectly. In a terrestrial ecosystem, major producers are herbaceous and woody plants.
- Primary producers in an aquatic ecosystem are phytoplankton, algae and higher plants.

- The energy trapped by the producer is either passed on to a consumer or the organism dies.
- Death of organism is the beginning of the detritus food chain/web.

Consumers (Heterotrophs)

These are all animals that depend on plants (directly or indirectly) for their food. They include :

(a) Primary consumers : They are herbivores which feed on plants. It includes insects, birds and mammals in terrestrial ecosystem and molluscs in aquatic ecosystem.

(b) Secondary consumers : They are primary carnivores which feed on herbivores. It includes frog, fox, man etc.

(c) Tertiary consumers : They are secondary carnivores which feed on primary carnivores.

- **A simple grazing food chain (GFC) is depicted below :**

Grass ----------→ Goat ----------→ Man
(Producer) (Primary Consumer) (Secondary Consumer)

- **Detritus Food Chain (DFC) :** It begins with dead organic matter.
- It is made up of decomposers i.e., saprotrophs which are heterotrophic organisms.
- It includes fungi and bacteria.
- They meet their energy and nutrient requirements by degrading dead organic matter or detritus.
- Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.
- In an aquatic ecosystem, GFC is the major conduit for energy flow.
- In a terrestrial ecosystem, a much larger fraction of energy flows through the DFC than through the GFC.
- DFC may be connected with GFC at some levels. Some of the organisms of DFC are prey to the GFC animals.
- Some omnivorous animals like cockroaches, crows etc., are also involved in the food chain.
- These interconnection of food chains make a **food web.**

Trophic Levels

- Based on their feeding relationship, organisms occupy a place in the natural surroundings or in a community.
- A specific place of organisms in the food chain is known as their trophic level.
- Producers belong to the first trophic level, herbivores to the second and carnivores to the third.
- The amount of energy decreases at successive trophic levels.
- When an organism dies it becomes dead biomass (detritus) that serves as an energy source for decomposers.
- Organisms at each trophic level depend on those at the lower trophic level for their energy demands.
- Each trophic level has a certain mass of living material at a particular time called as the standing crop. It is measured as the mass of living organisms (biomass) or the number in a unit area.
- **Biomass** of a species is expressed in terms of fresh or dry weight. Measurement of biomass in terms of dry weight is more accurate.
- The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows 10% law i.e., only 10% of the energy is transferred to each trophic level from the lower trophic level.
- It is possible to have so many levels such as producer, herbivore, primary carnivore, secondary carnivore in the grazing food chain.

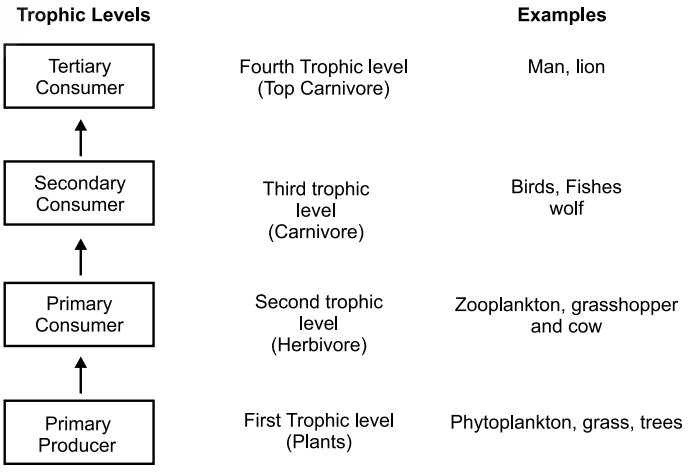

Fig. 6.2: Different Trophic Levels in an Ecosystem

ECOLOGICAL PYRAMIDS

- The representation of a food chain in the form of a pyramid is called ecological pyramid.
- The base of a pyramid is broad and it narrows down at the apex.
- The base of each pyramid represents the producers (first trophic level) while the apex represents tertiary or top level consumer.
- **There are three ecological pyramids, namely**
  - **(a)** Pyramid of number
  - **(b)** Pyramid of biomass
  - **(c)** Pyramid of energy
- In most ecosystems, all the pyramids are upright, i.e., producers are more in number than the carnivores.
- Also, energy at a lower trophic level is always more than at a higher level.

Pyramid of Number

Example - Grassland ecosystem

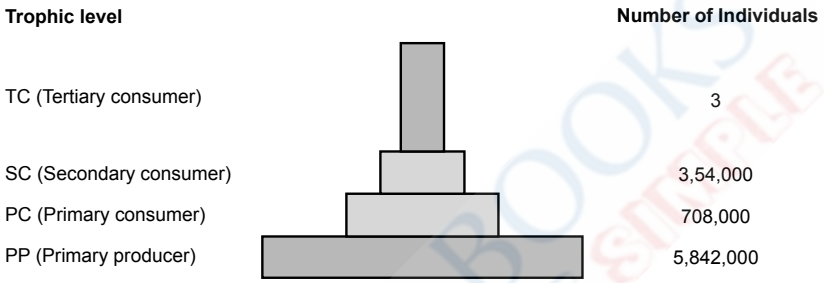

Fig. 6.3: Pyramid of Numbers in a Grassland Ecosystem

Pyramid of Biomass

It shows a sharp decrease in biomass at higher trophic levels.

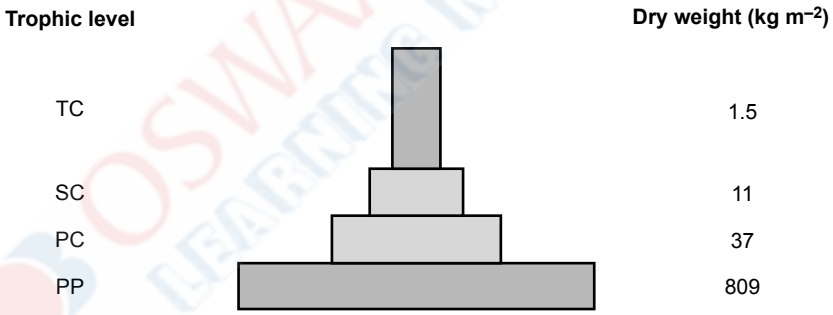

Fig. 6.4: Pyramid of Biomass

Pyramid of Energy

Primary producers convert only 1% of the energy in the sunlight available to them into NPP.

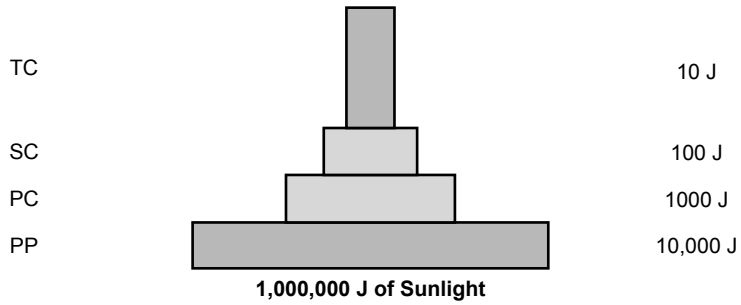

Fig. 6.5: An Ideal Pyramid of Energy

- Pyramid of energy is always upright, because when energy flows from a trophic level to the next trophic level, some energy is always lost as heat at each step.
- Any calculations of energy content, biomass or numbers has to include all organisms at that trophic level.

- The trophic level represents a functional level.
- A given species may occupy more than one trophic level in the same ecosystem at the same time.

  Example: A sparrow is a primary consumer when it eats seeds, fruits, peas and it becomes a secondary consumer when it eats insects and worms.

Inverted Pyramid of Biomass

(a) In aquatic habitats, the small standing crop of phytoplankton supports large standing crop of zooplankton. In this case, the pyramid of biomass is inverted.

Fig. 6.6: Inverted Pyramid of Biomass

(b) Pyramid of biomass in sea is generally inverted because the biomass of fishes far exceeds than that of phytoplankton.

(c) In a parasitic food chain, the pyramid of numbers is inverted. In this food chain, a single tree (producer) provides food to several fruit eating birds, which in turn support several insects.

- **Limitations of Ecological Pyramids :**
  - **(a)** It does not take into account the same species belonging to two or more trophic levels.
  - **(b)** It assumes a simple food chain that almost never exists in nature; it does not accommodate a food web.
  - **(c)** Saprophytes are not included in ecological pyramids even though they play a vital role in the ecosystem.

ECOLOGICAL SUCCESSION

- It is a gradual, slow and predictable change in the species composition of an area leading to a climax community (community that is in equilibrium with the environment).
- During succession some species colonize an area and become more numerous, whereas populations of other species decline and disappear.
- The entire sequences of communities that successively change in a given area are called **sere**.
- The individual transitional communities are termed **seral stages (seral communities).**
- In the successive seral stages, there is a change in the diversity of species, increase in the number of species and organisms and an increase in the total biomass.
- The present day communities are the results of succession that occurred over millions of years.
- Succession and evolution would have been parallel processes at that time.

Types of Succession

(a) Primary Succession

- The succession taking place in areas where no living organisms ever existed is known as primary succession. *e.g.*, newly cooled lava, bare rock, newly created pond or reservoir.
- Before a biotic community is established, there must be formation of fertile soil through natural processes. So, the primary succession is a very slow process.

(b) Secondary Succession

- The succession taking place in an area after the existed organisms are lost is known as secondary succession. *e.g.*, abandoned farm lands, burned or cut forests, lands that have been flooded.
- Since some soil or sediment is present, succession is faster than primary succession.
- The species that invade depends on the condition of the soil, availability of water etc.
- In succession, changes in vegetation affect food and shelter of various animals.
- Thus, as succession proceeds, the number and types of animals and decomposers also change.
- Natural or human induced disturbances (deforestation, fire etc.), can convert a particular seral stage of succession to an earlier stage.
- Such disturbances create new conditions that encourage some species and discourage or eliminate other species.

Succession of Plants

- Based on the nature of the habitat, succession of plants is of two types namely **hydrarch** and **xerarch**.
  - **(a) Hydrarch Succession**
    - It takes place in wetter areas.
    - The successional series progress from hydric to mesic conditions.

(b) Xerarch Succession

- It takes place in dry areas.
- The series progress from xeric to mesic conditions.
- Hence, all successions (both hydrarch and xerarch) lead to medium water conditions (mesic, the climax community).
- The species invading a bare area are called **pioneer** species.

➢ **Primary succession on rocks (xerophytic habitat)**

- In primary succession on rocks, lichens are the pioneer species which secrete acids to dissolve rock, helping in weathering and soil formation.
- These result in some very small plants like bryophytes, which take hold in the small amount of soil.
- With the passage of time, these are succeeded by bigger plants and after several more stages, ultimately as stable climax forest community is formed.
- The climax community remains stable as long as the environment remains unchanged.
- With time, the xerophytic habitat gets converted into a mesophytic one.

➢ **Primary succession in water :**

- In primary succession in water, the pioneer species are the small phytoplanktons. With the time, these are replaced by free-floating angiosperms, then by rooted hydrophytes, sedges, grasses and finally the trees.
- The climax again would be a forest.
- With time, the water body is converted into land.

➢ **Secondary Succession**

- In secondary succession, the species that invade depend on the condition of the soil, availability of water, the environment and also on the seeds or other propagules present.
- Since soil is already present, the rate of succession is much faster and hence, climax is also reached more quickly.

Mnemonics

(a) Concept: Hydrarch Succession	
Mnemonics:	
Pretty Starlets Feel Shy of Males with Charisma	
Interpretation:	
P	- Plankton
S	- Submerged plants
F	- Floating plants
S	- Swamps
M	- Marshy meadow
C	- Climax community

(b) Concept : Xerarch Succession	
Mnemonics:	
Large MAPS Collection	
Interpretation:	
L	- Lichens
M	- Mosses
A	- Annual grasses
P	- Perennial grasses
S	- Shrubs
C	- Climax community

NUTRIENT CYCLING

➢ Organisms need a constant supply of nutrients to grow, reproduce and regulate various body functions.

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

➢ It varies in different kinds of ecosystems and also on a seasonal basis.

➢ Nutrients are never lost from the ecosystems, but are recycled again and again.

➢ The movement of nutrient elements through various components of an ecosystem is called nutrient cycling (biogeochemical cycles).

➢ There are two types of nutrient cycles namely : Gaseous cycle and Sedimentary cycle.

(a) Gaseous Cycle

(a) The reservoir exists in the atmosphere.

(b) It includes nitrogen, carbon cycle, etc.

(b) Sedimentary Cycle

(a) The reservoir is located in Earth's crust.

(b) It includes sulphur and phosphorus cycle.

- Environmental factors (soil, moisture, pH, temperature,etc.) regulate the rate of release of nutrients into the atmosphere.
- The reservoir meets with the deficit of nutrients due to imbalance in the rate of influx and efflux.

Phosphorus Cycle

- Phosphorus is a constituent of biological membranes, nucleic acids and cellular energy transfer systems.
- Many animals use phosphorus to make shells, bones and teeth.
- The natural reservoir of phosphorus is rock (in the form of phosphates).
- When rocks are weathered, minute amounts of phosphates dissolve in soil solution and are absorbed by the 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.

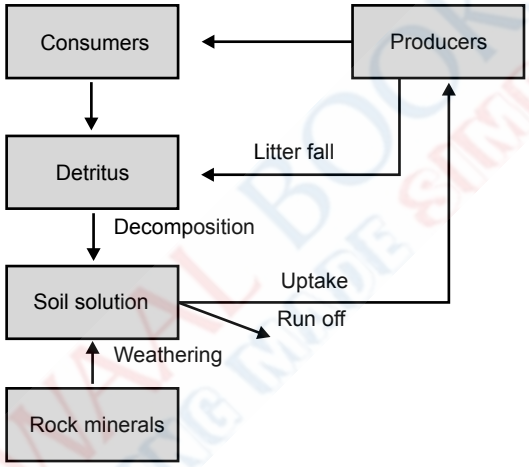

Fig. 6.7: Model of Phosphorus Cycle in a Terrestrial Ecosystem

Phosphorus Cycle

Phosphorus Cycle
Atmospheric input is much smaller.
Gaseous exchange is negligible.

Ecosystem Services

- The products of ecosystem processes are called ecosystem services, for example, healthy forest ecosystems purify air and water, mitigate droughts and floods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and provide aesthetic, cultural and spiritual values.
- Robert Constanza and his colleagues have tried to put price tags on nature's life-support services.
- Researchers have put an average price tag of US $ 33 trillion a year on these fundamental ecosystems services.
- This is nearly twice the value of the global gross national product GNP which is US $ 18 trillion.
- Out of the total cost of various ecosystem services, the soil formation accounts for about 50%.
- Contributions of other services like recreation & nutrient cycling are less than 10% each.
- The cost of climate regulation and habitat for wildlife are about 6 % each.

Know the Terms

- **Biogeochemical cycle/Nutrient cycle :** It refers to the continuous exchange of nutrients among organisms and between organisms and their physical environment.
- **Ecosystem Services :** It refers to the products of ecosystem process.

- **Food Chain :** It refers to the transfer of energy from the producer through a series of organism.
- **Food Web :** It refers to an interconnected matrix of food chains.
- **Herbivores :** Herbivores are the primary consumers which depend only on plants for their food needs.
- **Producers :** The green plants of an ecosystem are called producers.
- **Primary Carnivores :** These are the secondary consumers which depend on the herbivores for their food needs.
- **Secondary Carnivores :** These are the tertiary consumers which depend on the primary carnivores for their food needs.
- **Standing Crop :** It refers to the amount of biomass present at each trophic level.

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Chapter-7 : Biodiversity and its Conservation

TOPIC-1
Biodiversity and Its Patterns

Revision Notes

BIODIVERSITY

- In our biosphere immense diversity (or heterogeneity) exists not only at the species level but at all levels of biological organization.
- The term 'biodiversity' refers to the diversity of biological organization ranging from cellular macromolecules to biomes.
- The term 'biodiversity' was popularized by Edward Wilson.

LEVELS OF BIODIVERSITY

(a) Genetic Diversity

- It is the diversity shown by a single species at genetic level.

  e.g., *Rauwolfia vomitoria* grown in Himalayan ranges shows genetic variation in the potency and concentration of the chemical called reserpine.
- India has more than 50,000 different strains of rice and 1000 varieties of mango.

(b) Species Diversity

- It is the diversity at species level.

  e.g., Western Ghats have greater amphibian species than Eastern Ghats.

(c) Ecological Diversity

- It is the diversity at ecosystem level.

  e.g., In India, deserts, rain forests, mangroves, coral reefs, wetlands, estuaries & alpine meadows are seen whereas the Scandinavian countries (like, Norway, Sweden) have less ecological diversity.

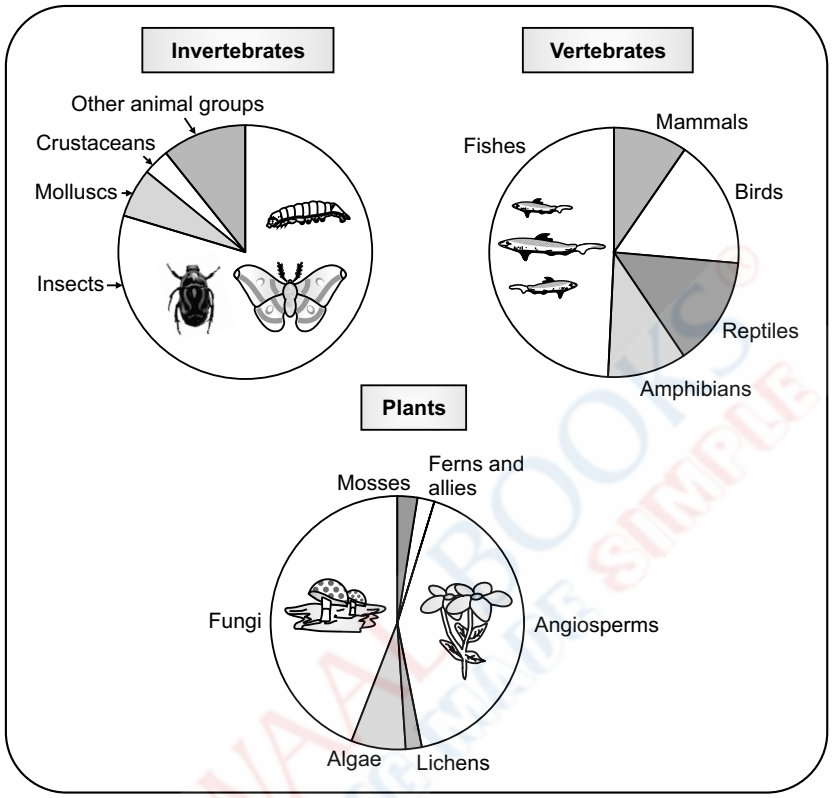
NUMBER OF SPECIES ON EARTH AND IN INDIA (GLOBAL SPECIES DIVERSITY)

Species on Earth

- According to IUCN (2004) : More than 1.5 million species are described so far.
- According to Robert May's global estimate, there are about 7 million species. As per May's global estimate only 22 per cent of the total species have been discovered.
- Animals are more diverse (above 70%) than plants including Plantae and Fungi (22%).
- Most species rich taxonomic group among animals are insects. They make up 70% *i.e.*, out of every 10 animals, 7 are insects.
- Number of fungi species is more than the combined total of the species of fishes, amphibians, reptiles & mammals.
- **Biologists are not sure about total number of prokaryotic species because :**
  - **(a)** Conventional taxonomic methods are not suitable for identifying microbial species.
  - **(b)** Many species are not culturable under laboratory conditions.

Species in India

- India has only 2.4% of world's land area, but has 8.1% of the species diversity.
- India is one of the 12 mega diversity countries of the world.
- Nearly 45,000 species of plants and twice as many of animals have been recorded from India.
- India would have more than 1 lakh plant species and 3 lakh animal species.



PATTERNS OF BIODIVERSITY

(a) Latitudinal Gradients

- Species diversity decreases from the equator to the poles.
- Tropics (latitudinal range of 23.5° N to 23.5° S) have more species than temperate or polar areas. Colombia (near equator) has about 1,400 species of birds.
- New York (41° N) : 105 species of birds.
- Greenland (71° N) : 56 species of birds.
- India (tropical latitudes) : More than 1,200 species of birds. Tropical forest region like Ecuador has upto 10 times species of vascular plants as compared to a forest of equal area in a temperate region like the Midwest of USA. Tropical Amazonian rain forest (South America) has the greatest biodiversity on earth.
- It contains more than 40,000 species of plants, 3,000 species of fishes, 1,300 species of birds, 427 species of mammals, 427 species of amphibians, 378 species of reptiles and more than 1,25,000 species of invertebrates.
- **Biodiversity (species richness) is highest in tropics because :**
  - **(a)** Tropical latitudes have remained relatively undisturbed for millions of years and thus had a long evolutionary time for species diversification.
  - **(b)** Tropical regions are relatively more constant and predictable (less seasonal).
  - **(c)** They receive more solar energy which contributes to greater productivity.

(b) Species–Area Relationship

- According to the study of Alexander von Humboldt "within a region, species richness increases with increasing explored area, but only up to a limit.''
- Relation between species richness and area for a wide variety of taxa gives a rectangular hyperbola.
- On a logarithmic scale, the relationship is a straight line described by the equation :

$$\log S = \log C + Z \log A$$

where, S= Species richness, A= Area, C= Y-intercept, Z= Slope of the line (regression co-efficient).

- The value of Z lies in the range of 0.1 to 0.2.
- In species-area relationship among very large areas like entire continents, slope of the line is steeper (Z value: 0.6 to 1.2).

  Example: For frugivorous birds and mammals in the tropical forests of different continents, the slope is 1.15.

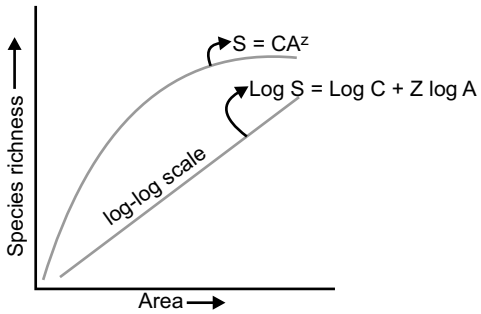


Fig. 7.1: Graph showing species area relationship

IMPORTANCE OF SPECIES DIVERSITY TO THE ECOSYSTEM

- The communities with more species are generally more stable than those with less species.
- A stable community should not show too much variation in productivity from year to year.
- Rich biodiversity is essential for ecosystem health and imperative for the very survival of human race on this planet.
- According to David Tilman, increased diversity contributed to higher productivity.
- **Rivet popper hypothesis:** This hypothesis was used by Stanford ecologist Paul Ehrlich. In an airplane, all parts are joined together using thousands of rivets (species). If every passenger travelling in air plane starts popping a rivet to take home (causing a species to become extinct), it may not affect flight safety (proper functioning of ecosystem) initially, but as more and more rivets are removed, the planes become dangerously weak over a period of time. Loss of rivets on the wings (key species that drives major ecosystem functions) is more serious threat to flight safety than loss of a few rivets on the seats or windows inside the plane.

LOSS OF BIODIVERSITY

- The biological wealth of our planet has been declining rapidly due to human activities.
- In last 20 years, 27 species have been disappeared.
- IUCN Red List (2004) says that 784 species (338 vertebrates, 359 invertebrates & 87 plants) were extinct in the last 500 years. Example: Dodo (Mauritius), Quagga (Africa), Thylacine (Australia), Stellar's Sea Cow (Russia) and 3 subspecies (Bali, Javan, Caspian) of tiger.
- 27 species have been disappeared in the last 20 years.
- More than 15,500 species are facing threat of extinction.
- 12% of all birds, 23% of all mammals, 32% of all amphibians and 31% of all gymnosperm species face the threat of extinction.
- The current extinction rate is 100 - 1,000 times faster than in the pre-human times.
- If this trend continues, nearly 50% species might be extinct within the next 100 years.

Impacts of Loss of Biodiversity

(a) Decline in plant production.

(b) Lowered resistance to environmental perturbations such as drought.

(c) Increased variability in ecosystem processes such as plant productivity, water use and pest and disease cycles.

Mnemonics

Concept: Causes of Biodiversity loss (Evil Quartet)	
Mnemonic: CHO Aldehyde	
Interpretation:	
C - Co Extinction	**H** - Habitat loss and Fragmentation
O - Over exploitation	**A** - Alien species invasions

CAUSES OF BIODIVERSITY LOSSES ('The Evil Quartet')

(a) Habitat Loss and Fragmentation:

- It is the most important cause.
- e.g., Tropical rain forests (loss from 14% to 6%).
- Thousands hectares of rain forests is being lost within hours.
- The Amazon rain forest is being cut for cultivating soya beans or for conversion of grasslands for cattle. Due to fragmentation, animals requiring large territories and migratory animals are badly affected.

Mnemonics

Concept: Animals extinct due to Over-Exploitation	
Mnemonic: Please Stop Over Exploitation	
Interpretation:	
P - Passenger pigeon	**S** - Stellar's sea cow

(b) Over-exploitation

- Due to over-hunting and over-exploitation of various plants and animals by humans, many species have become endangered or extinct.
- Many species like Stellar's sea cow, Passenger pigeon etc., are extinct due to over-exploitation by humans.

(c) Alien Species Invasions

- Some of the alien species turn invasive and cause decline or extinction of indigenous species.

  e.g., The Nile Perch introduced in Lake Victoria (East Africa) caused extinction of more than 200 species of cichlid fish.
- Invasive weed species like carrot grass (*Parthenium*), *Lantana* and water hyacinth (*Eichhornia*) caused damage to our native species.
- The illegal introduction of the African catfish (*Clarias gariepinus*) for aquaculture is posing a threat to the indigenous catfishes in our rivers.

Mnemonics

Concept: Alien Species invasion		
Mnemonic: NA PLEASE		
Interpretation:		
N - Nile Perch	**A** - African Catfish *(Clarias gariepinus)*	**P** - *Parthenium* (Carrot grass)
L - Lantana	**E** - *Eichhornia* (Water hyacinth)	**AS** - Alien Species

(d) Co-extinction

- When a species becomes extinct, the plant and animal species associated with it also become extinct.
- *e.g.,* - Extinction of the parasites when the host is extinct.
- Co-evolved plant-pollinator mutualism where extinction of one leads to the extinction of the other.

Know the Terms

- **Biodiversity :** Biodiversity is the variety of living forms present in various ecosystems.
- **Ecological/ecosystem diversity :** Diversity at the ecosystem level is called ecological diversity.
- **Genetic diversity :** It refers to the diversity of genes within a species.
- **Species diversity :** It refers to the variety of species within a region.
- **Latitudinal gradient :** It is the diversity index used to show the distribution of flora and fauna from the poles to the tropics.
- **Co-extinction :** It refers to the simultaneous extinction of multiple species where one is dependent on other species.
- **Exotic/Alien species :** These are species which are introduced into an ecosystem to which they are not native.

TOPIC-2
Conservation of Biodiversity

Revision Notes

Reasons for Conservation

(a) Narrowly Utilitarian Arguments

- Human derive economic benefits from nature such as food, firewood, fibre, construction material, industrial products (tannins, lubricants, dyes, resins, perfumes) and medicines.
- Other indirect benefits are pest control, climate moderation and flood control.
- More than 25% of the drugs are derived from plants.
- 25,000 species of plants have medicinal value.
- Exploring molecular, genetic and species-level diversity i.e., 'bioprospecting' for products of economic importance may enormously benefit nations with rich biodiversity.

(b) Broadly Utilitarian Arguments

- Biodiversity has many ecosystem services.
- Amazon forest produces 20% of total O_2 in the earth's atmosphere by the process of photosynthesis.
- Pollination service takes place through bees, bumble bees, birds and bats.
- We derive aesthetic pleasures such as walking through thick woods, watching spring flowers in full bloom or waking up to a bulbul's song in the morning.

(c) Ethical Arguments

- Every species has an intrinsic value.
- We have a moral duty to care for their well-being.

Conservation of Biodiversity

(a) *In-situ* conservation (on site)

- It is the conservation of genetic resources within natural or human-made ecosystem in which they occur.

  e.g., Protected areas such as National Parks, Sanctuaries, Biosphere reserves, cultural landscapes, natural monuments.

(i) National Park

- Strictly reserved for the welfare of the wildlife where private ownership, cultivation, grazing etc., are prohibited.
- There are 90 national parks in India.

(ii) Sanctuary

- Here, protection is given only to the animals/fauna.
- Collection of timbers, minor forest products and private ownership are allowed as long as they do not harm the animals.
- There are 448 wildlife sanctuaries in India.

Mnemonics

Concept: In situ conservation	
Mnemonic: HB WiNS	
Interpretation:	
H - Hot spot (34 in world, 03 in India)	**B** - Biosphere Reserves (13)
W - Wildlife Sanctuaries (448)	**N** - National parks (90)
S - Sacred Groves	

(iii) Biosphere Reserves

- Areas of land or coastal environments to conserve ecosystem and genetic resources contained there.
- There are 14 biosphere reserves in India.

(iv) Sacred Forests (Sacred Groves)

- Sacred groves are highly protected forests because of religious and cultural traditions.
- Sacred groves are found in Khasi and Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghat regions of Karnataka and Maharashtra and Sarguja, Chanda & Bastar areas of Madhya Pradesh.
- In Meghalaya, the sacred groves are the last refuges for a large number of rare and threatened plants.

(v) Hotspots

- These are the richest and the most threatened reservoirs of plant and animal life on the Earth.
- In total all the biodiversity hotspots cover less than 2% of the Earth's land area but could reduce the ongoing extinctions by almost 30%.
- There are 34 hotspots in the world.
- Three main hotspots (Western Ghats and Sri Lanka, Indo-Burma and Himalaya) cover India's biodiversity regions.

(b) *Ex-situ* conservation (off site)

- It is the conservation of organisms outside their habitats.
- In this approach, threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care, *e.g.,* genetic resource centres, zoological parks, botanical gardens, gene banks etc.
- In recent years, *ex-situ* conservation has advanced by preserving the gametes of threatened species in viable and fertile condition for long period using cryopreservation techniques, eggs can be fertilised *in-vitro*, and plants can be propagated using tissue culture methods.
- Seeds of different genetic strains of commercially important plants can be kept for long period in seed banks.

International Efforts for Conserving Biodiversity

- **The Earth Summit (Rio de Janeiro, 1992) - Three objectives :**
  - **(a)** Conservation of biodiversity
  - **(b)** Sustainable use of biodiversity
  - **(c)** Sharing of benefits in the utilization of genetic resources.
- **The World Summit on Sustainable Development** (Johannesburg, South Africa, 2002) : 190 countries pledged to reduce the current rate of biodiversity loss.

Know the Terms

- **Biosphere Reserves :** These are a kind of protected areas of land and coastal environment having unique biodiversity.
- **Cryopreservation :** It is the method of storage of materials at ultra-low temperature either by very rapid cooling or by gradual cooling and simultaneous dehydration at low temperature.
- **Exotic/Alien species :** These are species which are introduced into an ecosystem to which they are not native.
- **Hot Spots :** These are the priority areas of conservation that are extremely rich in species which have high endemism and are under constant threat of extinction.
- **Sacred Forests/groves :** These are the forest protected by tribal communities due to religious sanctity.
- ***Ex-situ* conservation :** The conservation of components of species outside their natural habitats.
- ***In-situ* conservation :** The conservation of species in their natural habitats.
- **Endemic species :** The species which are found only in a particular area because of isolation and climatic condition.
- **Sanctuary** : Protected area only for the fauna.
- **Red list :** A catalogue highlighting the challenged taxas that are on the verge of global extinction.

❑❑

Chapter-8 : Environmental Issues

Revision Notes

POPULATION EXPLOSION AND POLLUTION

- Human population explosion increases the demand for food, water, home, electricity, roads, automobiles etc.
- It leads to pollution of air, water and soil and depletion of valuable natural resources.
- The Government of India has passed the Environment (Protection) Act, 1986 to control environmental pollution and protect and improve the quality of our environment.

AIR POLLUTION AND ITS CONTROL

- The air pollution is caused due to undesirable change in the physical, chemical and biological characteristics of air.
- **Factors Involved in Air Pollution**
  - **(a)** Concentration of pollutants.
  - **(b)** Duration of exposure to the pollutants.
  - **(c)** Type of organism it affects.
- **Causes of Air Pollution :**
  - **(a)** Particulate and gaseous air pollutants from smokestacks of thermal power plants, smelters etc.
  - **(b)** Pollutants from automobiles.
  - **(c)** Usage of leaded petrol.
  - **(d)** Garbage decomposition.
- **Effects of Air Pollution**
  - **(a) Humans and Animals**
    - According to Central Pollution Control Board (CPCB), particulate size of less than 2.5 μm in diameter (PM 2.5) causes greatest harm such as respiratory problems, irritation, inflammations and damage to lungs and premature deaths.
    - It also causes cancer and genetic mutations.
  - **(b) Plants**
    - It causes fruit damage and various leaf diseases like necrosis, chlorosis etc.
    - It decreases the crop yield resulting in premature death of plants.
    - It increases infestation by pests.
- **Control of Air Pollution**
  - **(a) Electrostatic Precipitator**
    - It is the device widely used in industries to remove particulate matter.
    - It can remove over 99% particulate matter present in the exhaust from a thermal power plant.
    - It has electrode wires maintained at high voltage which produces electrons.
    - These electrons get attached to the dust particles, giving them negative charge.
    - The collecting plate grounded being positive charge attracts the negatively charged dust particles.
    - When the air passes through the collecting plate, it gets cleaned.
    - The velocity of air between the plates is maintained at low value to allow the dust to fall on the collecting plate.

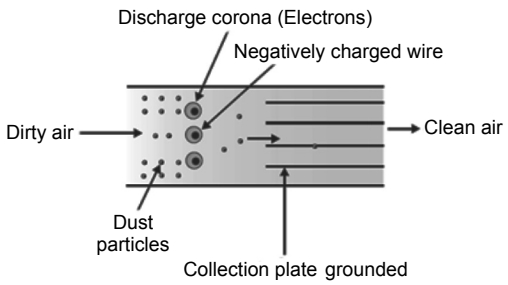


Fig. 8.1: Electrostatic precipitator

(b) Scrubber

- It is a device used to remove harmful gases like sulphur dioxide from the industrial exhausts.
- The exhausts are passed through a spray of lime or water.

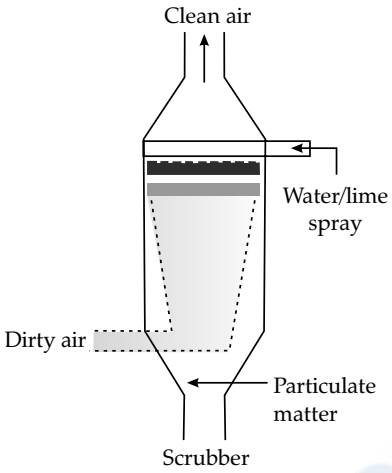


Fig. 8.2: Scrubber

- The water dissolves the gases and lime (CaO) reacts with sulphur dioxide to form a precipitate of calcium sulphate and sulphide.
- There are two types of scrubber namely, wet scrubber and dry scrubber.

(c) Catalytic Converters

- It is made up of expensive metals like platinum, palladium and rhodium.
- These are fitted into the automobiles for reducing emission of poisonous gases such as carbon monoxide, nitrogen dioxide etc.
- When the exhaust emission passes through the catalytic converter :
  - **(a)** Nitric oxide splits into nitrogen and oxygen.
  - **(b)** Carbon monoxide gets oxidized into carbon dioxide.
  - **(c)** Unburnt hydrocarbons get burnt completely into carbon dioxide and water.

➢ **Measures Taken by the Government to Control Air Pollution**

(a) Use of catalytic converters.
(b) Use of lead-free petrol or diesel.
(c) Phasing out of old vehicles.
(d) Using low-sulphur petrol and diesel.
(e) Application of pollution-level norms for vehicles, etc.

➢ **Laws and policies in India to control vehicular pollution**

(a) Application of Euro II norms in vehicles. According to this, sulphur must be controlled at 350 ppm in diesel and 150 ppm in petrol.
(b) Application of Bharat Stage II for all automobiles throughout the country from 1 April, 2005.
(c) All automobiles in eleven Indian cities had to meet Euro III emission specification by 1 April, 2005 and Euro IV by 1 April, 2010.
(d) Bharat stage IV norms are applicable to 13 cities along with NCR passenger cars and diesel vehicles.
(e) Bharat Stage IV is expected to be applied for two and three wheelers by 2016.

➢ **Controlling Vehicular Air Pollution : (A Case Study of Delhi)**

- With its very large population of vehicular traffic, Delhi leads the country in its levels of air-pollution. In the 1990s, Delhi ranked fourth among the 41 most polluted cities of the world. Air pollution problems in Delhi became so serious that a public interest litigation (PIL) was filed in the Supreme Court of India. After being censured very strongly by the Supreme Court, under its directives, the government was asked to take appropriate measures, including switching over the entire fleet of public transport, i.e., buses, from diesel to compressed natural gas (CNG). All the buses of Delhi were converted to run on CNG by the end of 2002.

- **Advantages of CNG :**
  - **(a)** CNG burns most efficiently leaving no unburnt remains behind.
  - **(b)** CNG is cheaper than petrol or diesel, cannot be siphoned off by thieves and adulterated like petrol or diesel.
- **Disadvantage of CNG :**
  - **(a)** CNG has difficulty in laying down pipelines to deliver CNG through distribution points/pumps and ensuring uninterrupted supply.

NOISE POLLUTION AND ITS CONTROL

- In India, the Air (Prevention & Control of Pollution) Act (1981) was amended in 1987 to include noise as an air pollutant.
- Noise is undesired high level of sound.
- The sound level above 150 dB, generated by take off of a jet plane or rocket may damage ear drums.
- **Causes of Noise Pollution**
  - **(a)** Use of music instruments, loudspeaker, crackers etc.
  - **(b)** Jet plane or rocket take off.
  - **(c)** Industrial, factory and traffic noises.
- **Harmful Effects of Noise Pollution**
  - **(a)** Noise causes psychological and physiological disorders.
  - **(b)** Sleeplessness and increased heartbeat.
  - **(c)** Altered breathing pattern, stress etc.
  - **(d)** Hearing disability.
- **Control of Noise Pollution**
  - **(a)** Using sound absorbent materials in industries and buildings.
  - **(b)** Creating horn-free zones around hospitals and schools.
  - **(c)** Sticking to permissible sound-levels of crackers and loudspeakers.
  - **(d)** Delimit the timings of using loudspeakers by framing laws.
  - **(e)** Silencers for automobiles, industries etc.

WATER POLLUTION AND ITS CONTROL

- Water bodies are lifeline of all living organisms.
- Water pollution refers to the contamination of water bodies due to changes in physical, chemical and biological properties of water that affect the living beings.
- Due to human activities, the ponds, lakes, stream, rivers, estuaries and oceans are becoming polluted.
- The Government of India has passed the Water (Prevention and Control of Pollution) Act, 1974 to safeguard our water resources.
- **Sources of Water Pollution**
  - **(a) Domestic Sewage and Industrial Effluents**
    - Domestic sewage contains biodegradable organic matter.
    - It is decomposed by microorganisms, which can multiply using these organic substances as substrates and hence utilize some of the components of sewage.
    - A mere 0.1 % impurities make domestic sewage unfit for human use.
    - They include suspended solids such as sand, silt, clay, colloidal materials such as faecal matter, bacteria, cloth, paper, fibres and dissolved materials like nitrate, ammonia, phosphate, sodium, calcium etc.
    - Solids are easy to remove while removal of dissolved materials, organic compounds and toxic metal ions are most difficult.
    - Domestic sewage from home and hospitals contain pathogen and cause diseases like typhoid, dysentery etc.
  - **(b) Industrial Wastes**
    - The industrial effluents from petroleum, paper and chemical manufacturing industries contain toxic heavy metals like mercury and organic compounds leading to biomagnification (biological magnification).

- Heated (thermal) waste water from electricity-generating units (e.g. thermal power plants) eliminates organisms sensitive to high temperature.
- It may enhance the growth of plants and fish in extremely cold areas but, only after causing damage to the indigenous flora and fauna.

(c) Agricultural Run-off

- The run-off from agricultural land is polluted with pesticides and fertilizers.
- It enters water sources by seeping into ground water or streams.

➢ **Effects of Water Pollution**

(a) Biological Oxygen Demand

- The amount of biodegradable organic matter in sewage water is estimated by measuring Biochemical Oxygen Demand (BOD).
- During biodegradation, micro-organisms consume a lot of oxygen.
- It results in a sharp decline in dissolved oxygen causing death of aquatic organisms.
- The prime contaminants are nitrates and phosphates, which act as plant nutrients.
- They overstimulate the growth of algae, causing scum and unpleasant odours, and robbing the water of dissolved oxygen vital to other aquatic life.
- At the same time, other pollutants flowing into a lake may poison whole populations of fish; whose decomposing remains, further deplete the water's dissolved oxygen content.

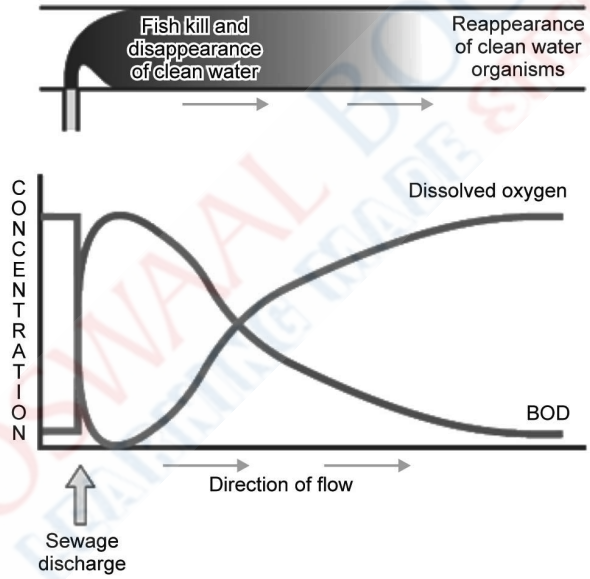


Fig. 8.3: Effect of Sewage Water on River

(b) Eutrophication

- It is the natural aging of a lake by nutrient enrichment of its water.
- In a young lake, the water is cold and clear.
- With time, due to introduction of nutrients such as nitrogen, phosphorus etc., increases the growth of aquatic organisms
- As the lake's fertility increases, plants and animals grow rapidly, and organic remains are deposited on the lake bottom.
- Slowly, the slit and organic debris pile up and the lake grows shallower and warmer, with warm-water organisms.
- Marsh plants take root in the shallows and fill in the original lake basin and eventually the lake gets converted into land.
- **Cultural or Accelerated Eutrophication:** The acceleration of ageing process due to heavy discharge of pollutants from the industries and home is known as cultural or accelerated eutrophication.

(c) Algal Bloom

- The presence of large amount of nutrients in water causes excessive growth of planktonic algae or algal bloom.

- It imparts a distinct colour to the water bodies and deteriorates the water quality resulting in death of fishes. Some bloom-forming algae are extremely toxic to human beings and animals.
- For example, the water hyacinth *(Eichhornia crassipes)* is the most problematic aquatic weed (Terror of Bengal').
- They grow faster than our ability to remove them.
- It leads to an imbalance in the ecosystem dynamics of the water body.

(d) Biomagnification

- To protect the crops from the several diseases and pests, a large number of pesticides are used. These pesticides reach the soil and are absorbed by plants with water and minerals from the soil.
- Due to rain, these chemicals can also enter water sources and into the body of aquatic plants and animals. As a result, chemicals enter the food chain. Since these chemicals cannot be decomposed, they keep on accumulating at each trophic level. The maximum concentration is accumulated at the top carnivore's level. This increase in the concentration of pollutants or harmful chemicals with an increase in the trophic level is called biological magnification or biomagnification.
    - For example, high DDT concentrations were found in a pond. The producers (phytoplankton) were found to have 0.04 ppm concentration of DDT. Since many types of phytoplankton were eaten by zooplankton (consumers), the concentration of DDT in the bodies of zooplankton was found to be 0.23 ppm. Small fish that feed on zooplankton accumulate more DDT in their body. Thus, large fish (top carnivore) that feed on several small fish have the highest concentration of DDT.

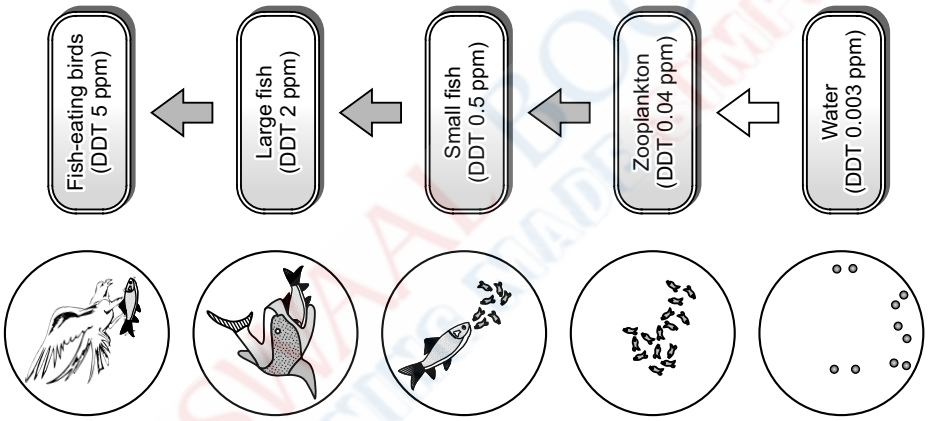


Fig. 8.4: Biomagnification of DDT in an aquatic food chain

➢ **Control of Water Pollution**

(a) Sewage contains a large quantity of human excreta, organic matter and microbes which should be treated first in sewage treatment plant before discharging into water bodies.

(b) Judicious use of small doses of fertilizers and manure.

- **A Case Study of Integrated Waste Water Treatment**
    - It includes artificial and natural processes.
    - An example of such an initiative is the town of Arcata, situated along the northern coast of California.
    - Collaborating with biologists from the Humboldt State University, the town people created an integrated waste water treatment process within a natural system.
- **The cleaning occurs in two stages :**

(a) Sedimentation, filtering and chlorine treatments.

- After this stage, lots of dangerous pollutants like dissolved heavy metals still remain.
- To combat this, an innovative approach was taken.

(b) The biologists developed a series of six connected marshes over 60 hectares of marshland.

- Appropriate plants, algae, fungi and bacteria were seeded into this area, which neutralize, absorb and assimilate the pollutants.
- Hence, as the water flows through the marshes, it gets purified naturally.
- The marshes also constitute a sanctuary, with a high level of biodiversity in the form of fishes, animals and birds that now reside there.

- A citizens group called **Friends of the Arcata Marsh** (FOAM) is responsible for the upkeep and safeguarding of this wonderful project.

Ecological Sanitation [EcoSan]

- It is a sustainable system for handling human excreta, using dry composting toilets.
- Ecological sanitation is a sustainable system for handling human excreta using dry composting toilets.
- There are 'EcoSan' toilets in many areas of Kerala and Sri Lanka.
- **Advantages of EcoSan**
  - **(a)** This is a practical, hygienic, efficient and cost-effective solution of human waste disposal.
  - **(b)** Human excreta can be recycled into a resource (as natural fertilizer), which reduces the need for chemical fertilizers.

SOLID WASTES

- Solid wastes refer to everything that goes out in trash.
- **Sources of Solid Wastes**
  - **(a) Municipal Solid Wastes**
    - These are wastes from homes, offices, stores, schools, hospitals, etc., that are collected and disposed by the municipality.
    - It includes paper, food wastes, plastics, glass, metals, rubber, leather, textile, etc.
  - **(b) Industrial Wastes**
    - These are wastes from industries.
    - It includes scraps, toxic heavy metals and oxides of iron, silica and aluminium.
  - **(c) Hospital Wastes**
    - These are the wastes from hospitals.
    - It includes disinfectants and other harmful chemicals.
  - **(d) E-wastes**
    - These are the wastes from electronic goods.
    - It includes damaged electronic goods and irreparable computers.
    - Over half of the e-wastes generated in the developed world are exported to developing countries, mainly to China, India and Pakistan, where metals like copper, iron, silicon, nickel and gold are recovered during recycling process.
- **Methods of Solid Wastes Disposal**
  - **(a) Open Burning**
    - Open burning reduces the volume of the wastes, although it is generally not burnt to completion and open dumps often serve as the breeding ground for rats and flies.
  - **(b) Sanitary landfills**
    - This method was adopted as the substitute for open-burning dumps.
    - In this method, wastes are dumped in a depression or trench after compaction, and covered with dirt every day.
  - **(c) Incineration**
    - Hospitals generate hazardous wastes that contain disinfectants and other harmful chemicals, and also pathogenic micro-organisms.
    - The incinerators are used to dispose hospital wastes.
  - **(d) Recycling**
    - It is the only way to manage e-wastes. It is done in an eco-friendly way.
    - It can be done in specifically built factories or manually.
  - **(e) Rag-pickers and Kabadiwallas**
    - It helps to collect and separate out wastes into reusable or recyclable.

CLASSIFICATION OF WASTES

- All wastes can be categorized into three types namely,
  - **(a)** Biodegradable.

(b) Recyclable.

(c) Non-biodegradable.

- The biodegradable materials can be put into deep pits in the ground and be left for natural breakdown, that leaves only the non-biodegradable to be disposed-off. *e.g.,* Compost, sewage, livestock waste etc.
- The non-biodegradable materials cannot be decomposed or degraded by microbes and hence becomes complex and toxic. *e.g.*, DDT, BHC, polythene bags.
- State Governments are trying to push for reduction in use of plastics and use of eco-friendly packaging.
- We can use cloth or other natural fibre carry-bags instead of polythene bags for shopping.

A Case Study of Remedy for Plastic Waste

- Ahmed Khan, a plastic sack manufacturer in Bangalore developed Polyblend.
- It is a fine powder of recycled modified plastic.
- Polyblend is mixed with the bitumen and is used to lay roads.
- Blend of Polyblend and bitumen enhances the bitumen's water repellent properties and helps to increase road life.

Case Study of Organic Farming

- Ramesh Chandra Dagar, a farmer in Sonipat, Haryana included bee-keeping, dairy management, water harvesting, composting and agriculture in a chain of processes, which support each other and allow an extremely economical and sustainable venture.
- There is no need of chemical fertilisers, as cattle excreta (dung) are used as manure.
- Crop waste is used to create compost, which can be used as a natural fertilizer or can be used to generate natural gas for satisfying the energy needs of the farm.
- Dagar has created the Haryana Kisan Welfare Club, with a membership of 5000 farmers to spread information on the practice of integrated organic farming.

RADIOACTIVE WASTES

- Nuclear energy was thought to be a non-polluting way of producing energy.

  But, the use of nuclear energy was found to have two serious problems namely,

  (a) Accidental leakage. *e.g.*, Incident in the Three Mile Island and Chernobyl incidents.

  (b) Safe-disposal
- **Effects of Radioactive Wastes**

  (a) Radiation from nuclear waste is causing an extreme damage to organisms, as it causes mutations at a very high rate.

  (b) At high doses, nuclear radiation is lethal but at lower doses, it creates various disorders.
- **Disposal Method**

  (a) It has been recommended that storage of nuclear waste, after sufficient pre-treatment, should be done in suitably shielded containers buried within the rocks, about 500 m deep below the earth's surface.

  (b) However, this method of disposal is meeting stiff opposition from the public.

Know the Terms

- **Algal Bloom :** The excess proliferation of planktonic algae imparting distinct colour and odour to the water is called algal bloom.
- **Biodegradable Pollutants :** Those pollutants which can be broken into simpler and harmless substances by the action of decomposers or microbes are called biodegradable pollutants.
- **Biological/Biochemical Oxygen Demand [BOD] :** It is a measure of oxygen required by aerobic decomposers for the biochemical degradation of biodegradable organic wastes.
- **Biomagnification :** It refers to increase in concentration of the toxicant at successive trophic levels.
- **DDT :** Dichloro diphenyl trichloroethane.
- **CNG :** Compressed Natural Gas.
- **Decibel (dB) :** A unit used to measure the intensity of a sound.
- **Deforestation :** It is the conversion of forested areas into non-forested ones.
- **Desertification :** It is the degradation of fertile land into barren land.

- **Electronic Wastes (E-wastes) :** The irreparable computers and other electronic goods are known as electronic wastes.
- **Eutrophication :** It is the natural aging of a lake by nutrient enrichment of its water.
- **Noise :** It is undesirable high level of sound.
- **Non-Biodegradable pollutants :** Pollutants which cannot be broken into simpler and harmless substances by the action of decomposers or microbes are called non-biodegradable pollutants.
- **Defunct Ships :** A type of solid waste that need proper disposal.
- **Oil Spill :** Spontaneous discharge of oil, petroleum in estuaries and oceans.

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