UNIT-VIII : BIOLOGY AND HUMAN WELFARE

CHAPTER-1
HUMAN HEALTH AND DISEASES

Revision Notes

Health and Related Aspects, Common Human Diseases and Immunity

➢ **Health**

- Health is a state of complete physical, mental and social well-being.
- Health is affected by genetic disorders, infections, sedentary lifestyle (Junk food, lack of exercise, habits, etc.).

Human Diseases and Immunity

- **Disease :** A disease can be defined as any condition that may lead to discomfort, distress, health problems or death of the affected person.
- **Congenital diseases :** These are diseases that are present since birth. For instance, a hole in the heart of an infant. They are caused by some genetic abnormalities or metabolic disorder or malfunctioning of an organ.
- **Acquired diseases :** These are diseases that may occur after birth during one's lifetime.

➢ **Based on their ability or inability to spread from one individual to another, Acquired diseases are of two types :**

(a) Infectious or Communicable diseases : The diseases which can be transmitted from a diseased person to a healthy person through infectious agents are known as infectious or communicable diseases. For example, tuberculosis, measles, malaria, etc.

(b) Non-infectious or Non-communicable diseases : The diseases which cannot be transmitted from an affected individual to a healthy person are known as non-infectious or non-communicable diseases. For example, high blood pressure, cancer, allergy, obesity, etc.

- Among non-infectious diseases, cancer is the major cause of death.
- Pathogens are disease-causing organisms.
- Parasites are pathogens as they harm the host by living in or on them.
- Pathogens have adapted to live within the host.

➢ **Common Infectious Diseases in Man**

1. BACTERIAL DISEASES

(a) Typhoid

- **Pathogen :** *Salmonella typhi*.
- **Mode of transmission** : It enters the small intestine through food and water and migrates to other organs through blood.
- **Symptoms :** Sustained high fever (39°- 40°C), weakness, stomach pain, constipation, headache and loss of appetite. Intestinal perforation and death may occur.
- **Confirmation :** The Widal test is used for confirmation of the disease.

(b) Pneumonia

- **Pathogen :** *Streptococcus or Diplococcus pneumoniae* and *Haemophilus influenzae.*
- **Mode of transmission :** Inhaling the droplets/aerosols released by an infected person. Sharing glasses and utensils with an infected person.
- **Symptoms :** Infects lung's alveoli. The alveoli get filled with fluid leading to respiratory problems. Fever, chills, cough, headache.
- **Severe cases :** Lips and fingernails turn bluish.
- Dysentery, plague, diphtheria are some other bacterial diseases in humans.

2. VIRAL DISEASES

(a) Common cold

- **Pathogen :** Rhino viruses
- **Mode of transmission** : Inhaling droplets resulting from cough or sneezes of infected person or through contaminated objects.
- **Symptoms :** Inputs Nose and respiratory passage. Nasal congestion and discharge, sore throat, hoarseness, cough, headache, tiredness, etc., last for 3-7 days.

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3. PROTOZOAN DISEASES

(a) Malaria

- **Pathogen :** *Plasmodium* sp. *(P. vivax, P. malariae, P. ovale. and P. falciparum).*
- **Mode of transmission :** Biting of female *Anopheles* mosquito.
- **Symptoms :** Hemozoin causes chill and high fever recurring every 3-4 days.

Life cycle of *Plasmodium* : The life cycle of *Plasmodium* has three phases - *Schizogony*, *gamogony* and *sporogony*. Female *Anopheles* mosquito is the primary host, while man is the secondary host.

Life cycle of *plasmodium* in Man :

(a) The infective stage of *Plasmodium* is the sporozoite, which is injected into the blood of the human by the bite of female *Anopheles* mosquito.

(b) From the human blood, sporozoites reach the liver cells where they multiply.

(c) The liver cells rupture to liberate the parasites into the blood where they attack the RBCs, multiply and cause their rupture.

(d) The rupture is associated with the release of a toxin called hemozoin, which is responsible for the recurring chill and high fever within 3 - 4 days.

(e) The development of gametocytes takes place in the RBCs, which are of two types : male gametocytes or microgametocytes, and female gametocytes or macrogametocytes.

Life cycle of *Plasmodium* in Female *Anopheles* Mosquito

(a) When a female *Anopheles* mosquito sucks the blood of an infected human host, it receives the RBCs including gametocytes.

(b) Further development occurs in the stomach wall of the mosquito, the gametes fuse to form a zygote.

(c) The zygote undergoes further development to form sporozoites.

(d) The sporozoites after liberation from the stomach wall move to different organs in the body cavity, but many of them penetrate the salivary glands.

(e) When the female *Anopheles* mosquito bites a healthy person, the sporozoites are injected in his / her blood along with saliva.

(b) Amoebiasis (Amoebic dysentery) or Enteritis.

- **Pathogen :** *Entamoeba histolytica*, found in the large intestine of humans.
- **Mode of transmission :** Houseflies (mechanical carriers) transmit parasites from the faeces of an infected person to food and water and thereby contaminate them.
- **Symptom :** Constipation, abdominal pain and cramps, stools with excess mucous and blood clots.

4. HELMINTH DISEASES

(a) Ascariasis

- **Pathogen :** *Ascaris* (Intestinal parasite).
- **Mode of transmission :** Soil, water, vegetables, fruits etc. contaminated with faeces containing eggs of parasites.
- **Symptoms :** Internal bleeding, muscular pain, fever, anaemia and blockage of intestinal passage.

(b) Filariasis (Elephantiasis)

- **Pathogen :** Filarial worms or *Wuchereria* (*W. bancrofti* and *W. malayi*).
- **Mode of transmission** : Bite of female *Culex* mosquito.
- **Symptoms :** Filarial worms live in lymphatic vessels (usually of lower limbs). It causes chronic inflammation of the organs, in which they live for many years. Limbs and genital organs may be deformed.

5. FUNGAL DISEASES

(a) Ring worms

- **Pathogens :** *Microsporum, Trichophyton* and *Epidermophyton*. They are seen in groin and between the toes.
- **Mode of transmission :** From soil or by using towels, cloths, comb, etc., of an infected person. Heat and moisture help fungi to grow.

- **Symptoms :** Appearance of dry, scaly lesions on various body parts such as skin, nails and scalp. Intense itching.

Other Infectious Diseases

(i) **Bacterial Diseases**

Disease	Pathogen	Transmission
Dysentery	*Shigella*	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*	Contact with rodents, dogs, etc.

(ii) **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	Airborne droplets
Chickenpox	*Varicella zoster*	Airborne droplets
Smallpox	Variola virus	Direct contact
Polio	Polio virus	Faeces & Air
Chikungunya	CHIK virus	*Aedes* mosquito
Avian flu	H_5N_1 virus	Contact with infected poultry. Airborne spread.
H_1N_1 (Swine flu)	H_1N_1 virus	Contact with pigs, cough & sneeze of an infected person.

Prevention and Control of Diseases

1. Personal Hygiene : Keep the body clean. 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) Standard practices of hygiene in a public gathering.
(e) Control and eliminate the vectors (*e.g.*, mosquitoes) and their breeding places by following methods :
- **(i)** Avoid stagnation of water.
- **(ii)** Regular cleaning of household coolers.
- **(iii)** Use of mosquito nets.
- **(iv)** Introduce larvivorous fishes like *Gambusia* in ponds.
- **(v)** Spraying insecticides in ditches, drainage and swamps.
- **(vi)** Doors and windows should be provided with wire mesh to prevent the entry of mosquitoes.

➢ These precautions can avoid vector-borne diseases like malaria, filariasis, dengue and chikungunya.

➢ Immune System

- It is the system that gives immunity to the body by recognizing, responding and remembering foreign antigens.
- It plays an important role in an allergic reaction, auto-immune disease 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 occurs.
- These are of two types namely; primary lymphoid organs and secondary lymphoid organs.

(a) **Primary Lymphoid Organs**

- Here, immature lymphocytes differentiate into antigen-sensitive lymphocytes *e.g.*, Bone marrow and thymus.
- Bone marrow is the main lymphoid organ and is the site of formation of all the blood cells including lymphocytes.
- Thymus is large during birth but gradually reduces in size and becomes very small in size at puberty.
- Growth and maturation of T-lymphocytes takes place here.

(b) **Secondary Lymphoid Organs**

- The organs to which matured lymphocytes migrate, interact with antigens and then proliferate to become effector cells *e.g.*, Spleen, lymph nodes, tonsils, Peyer's patches, MALT (mucosa-associated lymphoid tissue) and appendix are called secondary lymphoid organs.

(i) **Spleen :**

(i) It is a bean-shaped organ.
(ii) It contains lymphocytes and phagocytes.
(iii) It removes worn-out RBCs and micro-organisms from blood.
(iv) It is a reservoir of erythrocytes in the foetus.

(ii) **Lymph Nodes**

(i) These are found in the lymphatic system.
(ii) They trap micro-organisms or other antigens that enter the lymph and tissue fluid.
(iii) The trapped antigens activate lymphocytes and cause an immune response.

(iii) **Mucosa Associated Lymphoid Tissue (MALT) :**

(i) It is located within the lining of respiratory, digestive and urinogenital tracts.
(ii) It constitutes 50% of lymphoid tissue in the human body.

➢ Immunity

- It is the ability of the immune system of the body to fight against the disease-causing organisms.
- It is of two types, namely Innate immunity and Acquired immunity.

(a) Innate Immunity

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

(i) Physical Barriers

- Skin on our body is the first and main barrier that prevents entry of the micro-organisms. It is the first line of defence.
- Mucus coating of the epithelium lining in the respiratory, gastrointestinal and urogenital tracts also help in trapping microbes entering our body.

(ii) Physiological Barriers : Acid in the stomach, saliva in the mouth, tears from eyes–all prevent microbial growth.

(iii) Cellular Barriers : Certain types of leukocytes (WBCs) in our body like polymorpho-nuclear leukocytes (PMNL-neutrophils) and monocytes are natural killer (type of lymphocytes) in the blood, as well as macrophages in tissues can phagocytose and destroy microbes.

(iv) Cytokine Barriers : Virus-infected cells secrete proteins called *interferon* (type of cytokine) which protect non-infected cells from further viral infection.

(b) Acquired Immunity

- It is a pathogen-specific immunity.
- It is not present since birth but develops during the lifetime of an individual.
- It is characterized by memory *i.e.*, during the first encounter of a pathogen; our body produces a primary response in low intensity. The second encounter with the same pathogen produces a secondary (anamnestic) response in high intensity.
- The primary and secondary immune responses are carried out with B-lymphocytes and T-lymphocytes.
  (a) B-lymphocytes (B-cells) : Produce antibodies.
  (b) T-lymphocytes : Help B-cells to produce antibodies.

➢ Structure of an Antibody Molecule

- Each antibody has 4 polypeptide chains namely, 2 small light chains and 2 large heavy chains (H_2L_2).
- In our body different types of antibodies such as : IgG, IgA, IgM, IgE & IgD are produced.
- There are two types of acquired immunity namely humoral mediated response and cell-mediated response.

(a) Humoral or Antibody-Mediated Response/Antibody-Mediated Immunity (AMI)

- Antibodies are found in blood plasma. So, it is called as humoral immune response.
- It includes B-lymphocytes and T-lymphocytes. The latter help the former to produce antibodies.

(b) Cell-Mediated Response/Cell-Mediated Immunity (CMI)

- It is T-lymphocytes (T-cells) mediated (CMI).
- CMI causes Graft rejection.
- The body can differentiate 'self' and 'non-self'.
- Tissue matching and blood group matching are essential before undertaking any graft / transplant. After this, the patient has to take immune-suppressants for all his life.

➢ Acquired immunity is of two types *i.e.*, active and passive Immunity.

(a) Active Immunity

- The immunity in which antibodies are produced in a host body when the host is exposed to antigens (*e.g.*, living or dead microbes or other proteins) is known as active immunity.
- It is a slow process.
- It is produced in two ways :
  (a) Natural Active Immunity : During natural infection by microbes.
  (b) Artificial Active Immunity : Injecting the microbes deliberately during immunization.

(b) Passive Immunity :

- Here, readymade antibodies are directly given to protect the body.
- It is of two types :
  (a) Natural Passive Immunity : *e.g.*, Antibodies (IgG) from mother pass through Placenta to the Foetus, Antibodies (IgA) in colostrum received by the infants.
  (b) Artificial Passive Immunity : *e.g.*, Anti-tetanus serum (ATS).

➢ Immunization

- This is based on the 'memory' of the immune system.
- It is of two types namely; Active immunization and Passive immunization.

(a) Active Immunization (Vaccination)

- A preparation of vaccine (antigenic proteins of pathogen or inactivated pathogen) is introduced into the 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.
- The vaccines produced by conventional methods *e.g.*, small pox-vaccines are called first-generation vaccine. Those which are synthetic vaccine are the third generation vaccine.
- Vaccines are also produced using DNA recombinant technology (*e.g.*, Hepatitis B vaccine produced from Yeast). Such vaccines are called as second-generation vaccines.

(b) Passive Immunization

It is the direct injection of preformed antibodies or antitoxin. It is for quick immune response *e.g.*, Immunization against tetanus, snake venom, etc.

➢ Allergies

- It is the exaggerated or hypersensitive response of the immune system to certain antigens present in the environment.
- Allergens are substances causing allergy *e.g.*, mites in dust, pollens, animal dander, fur, etc.
- Antibodies produced against the allergens are of IgE type.
- Allergy is due to the release of chemicals like histamine and serotonin from the mast cells.
- **Symptoms :** Sneezing, watery eyes, running nose, difficulty in breathing, rashes etc.
- To determinate the cause of allergy. The patient is exposed to or injected with very small doses of possible allergens and the reactions were studied.
- **Treatment:** Drugs like anti-histamine, adrenaline and steroids quickly reduce the symptoms of allergy.
- Modern-day lifestyle results in lowering of immunity and more sensitivity to allergens.
- Asthma is a respiratory disease due to allergy.

➢ Auto Immunity

- It is caused due to genetic and other unknown reasons. The body attacks self cells. This results in auto-immune disease *e.g.*, Rheumatoid arthritis.
- The ability to differentiable foreign organisms from self cells is memory-based acquired immunity which is evolved in higher vertebrates.

➢ AIDS (Acquired Immunodeficiency Syndrome)

- Syndrome is a group of symptoms.
- AIDS is the deficiency of the immune system.
- It is caused by HIV (Human Immunodeficiency Virus), a retrovirus having an RNA genome.
- AIDS was first reported in America (1981).
- **Modes of Transmission :**
  - **(a)** Sexual contact with an infected person.
  - **(b)** Transfusion of contaminated blood and blood products.
  - **(c)** Sharing of infected needles.
  - **(d)** From infected mother to her child through the placenta.

➢ High risk of getting HIV includes

(a) Individuals with multiple sexual partners.
(b) Drug addicts who take drugs intravenously using infected syringes.
(c) Individuals who require a repeated blood transfusion.
(d) Children born to an HIV infected mother.

➢ HIV does not spread by touch or physical contact

- It spreads only through body fluids.
- There is always a time-lag (from few months to 5-10 years) between the infection and appearance of symptoms.

➢ Life Cycle of HIV Virus :

- HIV enters into body → To macrophages (acts as HIV factory) → RNA genome replicates in presence of *Reverse transcriptase* to form viral DNA → Viral DNA incorporates into host DNA → Infected cells produce virus particles (acts as HIV factory) → HIV also enters into helper T-cells (T_H) → Replicates and produce progeny viruses → Attack another helper T-cells → T-cells decrease → Weaken immunity.
- HIV infected person may be infected with *Mycobacterium*, viruses, fungi and parasites like *Toxoplasma*.

➢ Diagnosis of AIDS : ELISA test (Enzyme-linked immune-sorbent Assay) PCR-Test, western blotting, etc.

➢ Treatment of AIDS

- Anti-viral drugs are partially effective.
- They can only prolong the life of the patient.

➢ Prevention of AIDS

- Educate peoples about AIDS.
- Making blood (in blood banks) safe from HIV.
- Use of disposable needles and syringes.
- Advocating safe sex and free distribution of condoms.
- Controlling drug abuse.
- Regular check-ups for HIV in a susceptible population.

➢ Cancer

- Cancer is an abnormal and uncontrolled multiplication of cells resulting in the formation of tumor (masses of cells).
- Normal cells show a contact inhibition (contact with the other cells inhibits their uncontrolled growth). Cancer cells do not have this property.
- Tumors are of two types : namely, Benign tumor and Malignant tumor.
  - **(a) Benign Tumor**
    - It is confined to the place of its origin and does not spread to other parts of the body.
    - It causes less damage to the body.
  - **(b) Malignant Tumor**
    - It spreads and invades nearby tissues.
    - It is very much harmful in comparison to benign tumor.

➢ Metastasis : The spread of cancer cells from one part of the body to another.

➢ Types of Cancer

- Carcinoma : cancer of epithelial cells.
- Sarcoma : cancer of connective tissues.
- Melanomas : cancer of melanocytes.
- Leukemia : blood cancer.
- Lymphomas : cancer of spleen and lymph nodes.

➢ Causes of Cancer (Carcinogens)

(a) Physical agents : *e.g.,* Ionizing radiations like X-rays and gamma rays and non-ionizing radiations like UV.

(b) Chemical agents : Tobacco smoke (a major cause of lung cancer), vinyl chloride, caffeine, nicotine, mustard gas, etc.

(c) Biological agents : *e.g.,* oncogenic viruses, cellular oncogenes (c-onc) or proto oncogenes, etc. When a C-onc in normal cells is activated, the cells becomes oncogenic.

➢ Cancer Detection and Diagnosis

(a) Biopsy : A thin piece of the suspected tissue is stained and examined under a microscope (histopathological studies).

(b) In case of Leukemia : Biopsy and histopathological studies. Blood and bone marrow tests for increased cell counts.

(c) Radiography (use of X-rays) : CT (Computerized tomography) scan and MRI (Magnetic Resonance Imaging).

(d) Use of antibodies against cancer-specific antigens.

(e) Techniques of molecular biology to detect genes related to cancer in individuals with inherited susceptibility to certain cancers. Such individuals may be advised to avoid exposure to particular carcinogens (*e.g.,* tobacco smoke).

➢ Treatment of Cancer

Most cancers are treated by combination of surgery, radiotherapy and chemotherapy.

(a) Radiation therapy : Tumour cells are irradiated lethally without damaging surrounding normal tissues.

(b) Chemotherapy : Use of chemotherapeutic drugs. Many drugs have side effects like hair loss, anaemia, etc.

(c) Immunotherapy : The patients are given biological response modifiers (*e.g.,* α-interferon) which activates their immune system and helps in destroying the tumour.

IMPORTANT DIAGRAMS :

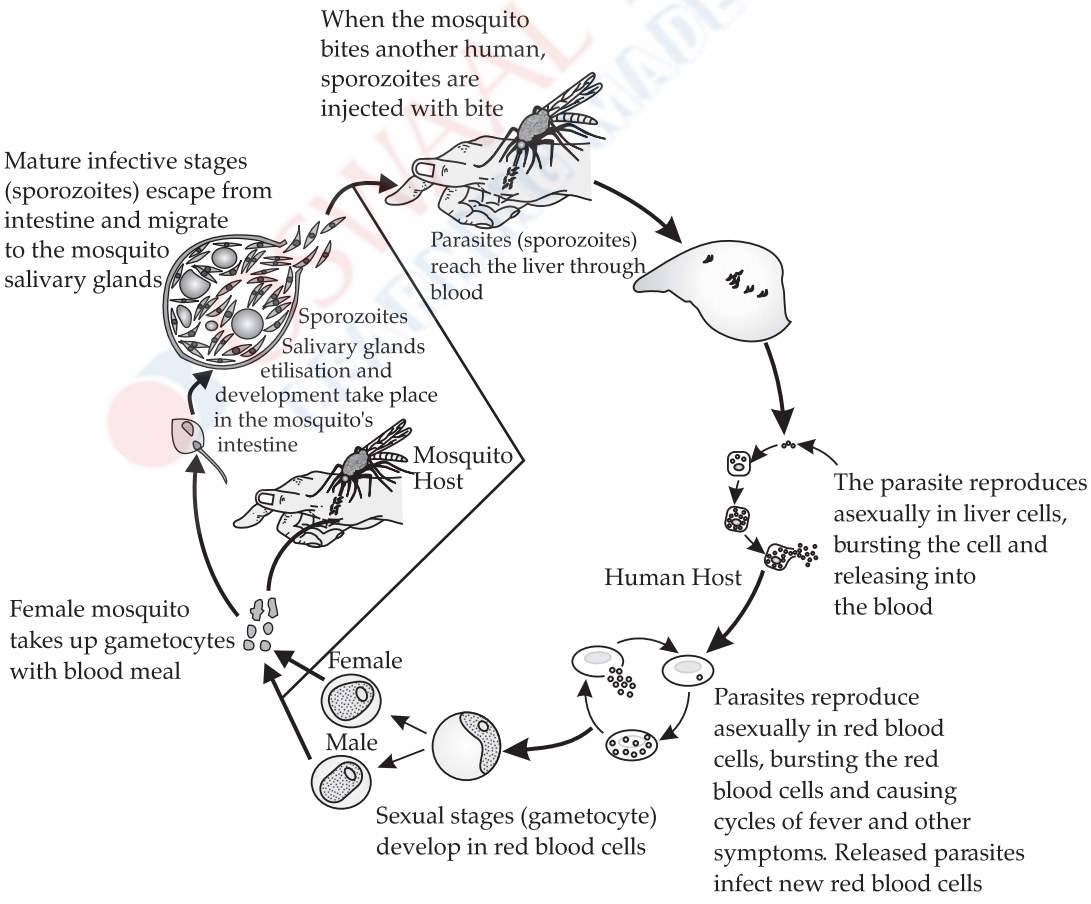

Fig 1.1 : Stages in the Life Cycle of *Plasmodium*

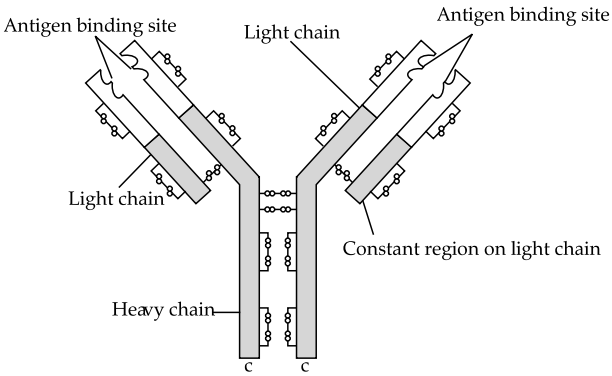

Fig 1.2 : Structure of an antibody molecule

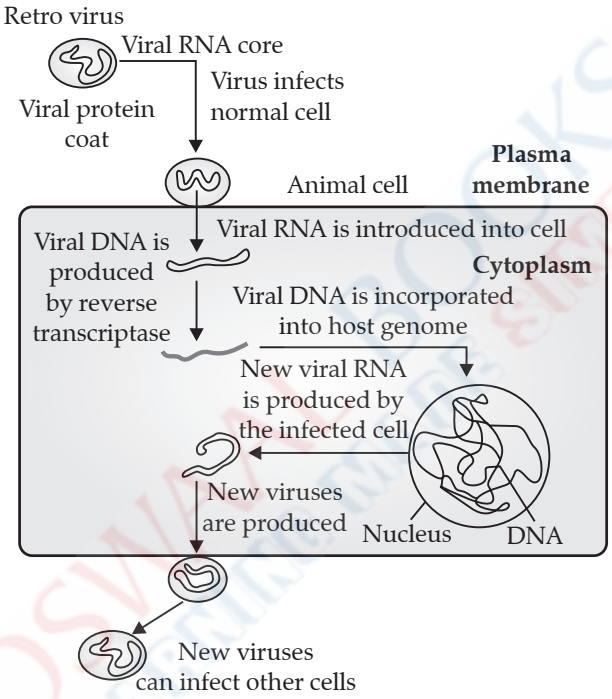

Fig 1.3 : Replication of Retrovirus

Mnemonics

1.

Human Health and Diseases

Concept : Bacterial diseases
Mnemonic : Bachelor of Physio Therapy
Interpretation : Bacteria, Pneumonia, Typhoid

2.

Human Health and Diseases

Concept : Helminth diseases
Mnemonic : He Finished Assignment
Interpretation : Helminth, Filariasis, Ascariasis

3.

Human Health and Diseases

Concept : Viral diseases
Mnemonic : Vice Chancellor
Interpretation : Viral, Common cold

4.

Human Health and Diseases

Concept : Protozoal diseases
Mnemonic : Pre Medical Association
Interpretation : Protozoa, Malaria, Amoebiasis

Drugs, Alcohol and Adolescence

Drugs and their effects

➢ Drugs

- These can alter the activity of the nervous system.
- They are also called as psychotropic drugs or mood-altering drugs or neurological drugs.
- These drugs change the mood, feelings, behaviour and power of perception.
- The sources of most of the drugs are mainly flowering plants and some fungi.

➢ Types of Drugs

- The drugs, which are commonly abused are opioid, cannabinoids and coca alkaloids.
- Main types of drugs are as follows :

1. Depressants

- Depress brain activity.
- They include

(a) Sedatives : Give calmness and relaxation. High doses induce sleep. *e.g., Barbiturates* (sleeping pills).

(b) Tranquilizers : Lower tension and anxiety without inducing sleep. *e.g., Benzodiazepines* (*e.g., Valium*).

2. Opiate Narcotics (Pain killers)

- Drugs that bind to specific opioid receptors in CNS and gastrointestinal tract.
- They are analgesic and depressant (lower tension, anxiety, B.P and respiration rate and reduce visual activity) *e.g.,* Opium and its derivatives (Opiates or Opioids).
- Opium is obtained from dried latex of unripe capsules of Poppy plant (*Papaver somniferum*).

➢ Opium Derivatives

(a) *Morphine :* Strong analgesic and sedative extracted from the latex of poppy plant. Useful during surgery.

(b) Heroin (Diacetyl morphine/smack) : Most dangerous, white, odourless, bitter crystalline compound produced by acetylation of morphine. It is a depressant and slows down body functions. It is taken by snorting and injection.

(c) *Codeine :* Mild analgesic. Used in cough syrups.

3. Stimulants

- Stimulates CNS *e.g., Cocaine, Caffeine* (cardiac stimulant), *amphetamines* (synthetic).
- *Amphetamines* & *anabolic steroids* are misused by some athletes.
- Coca alkaloid (Cocaine or coke / crack) : Obtained from the coca plant (*Erythroxylum coca*).
- Interferes the transport of neurotransmitter dopamine.
- Cocaine is usually snorted.
- Stimulate CNS producing euphoria and energy.
- Excessive dosage causes hallucination.

4. Hallucinogens

- Cause hallucinations, changing thoughts, feelings and perceptions *e.g., Mescaline, Psilocybin, Cannabinoids* & LSD (Lysergic Acid diethylamide).
- *Atropa belladonna* & *Datura* are plants with hallucinogenic property.

5. Cannabinoids

- Drugs (a group of chemicals) that interact with cannabinoid receptors in the brain.
- Generally taken by inhalation and oral ingestion.
- Natural cannabinoids are obtained from *Cannabis sativa* (Hemp plant). It's flower tops, leaves & resin are used to produce *bhang, ganja, charas* (*hashish*), *marijuana,* etc.
- Affects the cardiovascular system.

➢ Alcohol

- Alcohols include beverages and spirits.

  (a) Beverages : Wine, beer and toddy (5-15% alcohol).

  (b) Spirits : Whisky, brandy, rum, gin, arrack, etc. (more than 50% alcohol).
- The victims of alcoholism are known as alcoholics.

➢ Effects of Alcoholism

(a) Affects thinking ability, speech, movements, reflexes, etc.

(b) Amnesia, blurred vision, loss of body balance, nausea, vomiting, headache, etc.

(c) Cirrhosis and fatty liver.

(d) Alcoholic polyneuritis and loss of appetite.

(e) Cardiovascular diseases and hypertension.

(f) Ulcer, pancreatitis and gastritis.

(g) Loss of sexual drive and necrospermia.
(h) Foetal alcohol syndrome (FAS or Alcohol Embryopathy).
(i) Family and social problems.

➢ Why not to drink while drive

(a) Affects co-ordination and correct judgment of distance.
(b) Affects vision causing Tunnel vision.
(c) Increases reaction time.
(d) Affects behaviour.

➢ De-alcoholism

- Medical treatment.
- Social methods of treatment (Group therapy).
- Aversion therapy (Behavioural treatment).

➢ Smoking

- Tobacco is smoked, chewed or used as a snuff.
- Tobacco contains nicotine (an alkaloid) which stimulates the adrenal gland to release adrenaline and nor-adrenaline causing high BP and heart rate.
- Smoking causes cancers of lung, urinary bladder and throat, bronchitis, emphysema, coronary heart disease, gastric ulcer, etc. Tobacco chewing causes oral cancer.
- Smoking increases CO (Carbon monoxide) content in blood and reduces oxyhaemoglobin. This causes O_2 deficiency in the body.

➢ Adolescence

- It is 'a period' and 'a process' during which a child becomes mature in terms of his / her attitudes and beliefs for effective participation in society.
- Adolescence is a bridge linking childhood and adulthood (period of 12-18 years of age). It is very a vulnerable phase of mental and psychological and physical development.
- **Causes of Drug or Alcohol use in Adolescence period**

(a) Curiosity and experimentation.
(b) Need for adventure and excitement.
(c) To escape problems.
(d) Stress to excel in academics or examination.
(e) Television, movies, newspapers, internet etc.
(f) Unstable or unsupportive family structures and peer pressure.

➢ Addiction

- It is a psychological attachment (euphoria and a temporary feeling of well being) with drugs and alcohol.
- With repeated use of drugs, the tolerance level of the receptors increases. Thus, the receptors respond only to higher doses leading to greater intake and addiction.

➢ Dependence

- It is the tendency of the body to manifest a characteristic and unpleasant withdrawal syndrome if a regular dose of drugs / alcohol is abruptly discontinued.
- This results in anxiety, shakiness, nausea and sweating.
- Dependence leads to social adjustment problems.

➢ Effects of Drug or Alcohol Abuse

(a) Reckless behaviour, vandalism and violence.
(b) Coma and death due to respiratory failure, heart failure or cerebral haemorrhage.
(c) Drugs together with alcohol may cause death.
(d) Drop in academic performance and absence from school.
(e) Lack of interest in personal hygiene.
(f) Withdrawal and isolation.
(g) Depression, fatigue, aggressive and rebellious behaviour, the deteriorating relationship between family and friends.
(h) Loss of interest in hobbies.
(i) Fluctuations in sleeping, eating habits, weight, appetite, etc.
(j) Social problems like stealing and the spread of infectious diseases (*e.g.*, AIDS, hepatitis B).
(k) Damage of the nervous system and cirrhosis.
(l) Use of drugs and alcohol by pregnant woman adversely affects the foetus.
(m) Misuse of drugs by athletes (*e.g.*, narcotic analgesics, anabolic steroids, diuretics and certain hormones to increase muscle strength and bulk and to promote aggressiveness).

- **Side Effects of Anabolic Steroid in Females**
  - **(a)** Masculinisation
  - **(b)** Mood swings and depression
  - **(c)** Excessive hair growth
  - **(d)** Deepening of voice
  - **(e)** Increased aggressiveness
  - **(f)** Abnormal menstrual cycle
  - **(g)** Enlargement of clitoris
- **Side Effects of Anabolic Steroid in Males**
  - **(a)** Acne
  - **(b)** Mood swings and depression
  - **(c)** Increased aggressiveness
  - **(d)** Reduced testicles
  - **(e)** Decreased sperm
  - **(f)** Kidney and liver dysfunction
  - **(g)** Breast enlargement
  - **(h)** Premature baldness
  - **(i)** Enlargement of the prostate gland
- **Side Effects in the Adolescent - Male and Female**
  - Severe facial and body acne.
  - Premature closure of the growth centres of the long bones resulting in stunted growth.
- **Prevention and Control**
  - **(a)** Avoid undue peer pressure.
  - **(b)** Education and counselling.
  - **(c)** Seeking help from parents and peers.
  - **(d)** Looking for danger signs.
  - **(e)** Seeking professional and medical help.
  - **(f)** Psychologists and psychiatrists.
  - **(g)** De-addiction and rehabilitation programs.

Know the Terms

- **Health :** It is a state of complete physical, mental and social well-being.
- **Disease :** A disease can be defined as any condition that may lead to discomfort, distress, health problems or death of the affected person.
- **Congenital Diseases :** Diseases which are present since birth.
- **Acquired Diseases :** Diseases which may occur after birth during one's lifetime.
- **Infectious or Communicable diseases :** The diseases which can be transmitted from diseased person to healthy person by means of infectious agents.
- **Non-infectious or Non-communicable diseases :** The diseases which cannot be transmitted from an affected individual to a healthy person.
- **Pathogens :** Pathogens are disease causing organisms.
- **Immune system :** It is the system that gives immunity to the body by recognizing, responding and remembering foreign antigens.
- **Immunity :** It is the ability of body to protect itself from infections and diseases.
- **Innate (non-specific) immunity :** It is the non-specific type of defence that is present at the time of birth.
- **Acquired (specific) immunity :** It is pathogen specific immunity.
- **Active immunity :** It is a type of acquired immunity in which the body produces its own antibodies against disease-causing antigens.
- **Passive immunity :** It is a type of acquired immunity in which ready-made antibodies are transferred from one individual to another.
- **Vaccination :** It is defined as protection of the body from communicable diseases by the administration of some agents that mimic the antigen.
- **Allergy :** Allergy is the exaggerated response of the immune system to certain antigens present in the environment.
- **Autoimmunity :** It is the memory based acquired immunity, which is able to distinguish foreign molecules or cells (pathogens) from self-cells.

- **Cancer :** Cancer is an abnormal and uncontrolled multiplication of cells resulting in the formation of tumour.
- **Metastasis :** Metastasis is the pathological process of spreading cancerous cells to the different parts of the body.
- **Addiction :** It is a psychological attachment to certain effects such as euphoria and a temporary feeling 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/alcohol is abruptly discontinued.

❑❑

CHAPTER-2
MICROBES IN HUMAN WELFARE

Revision Notes

Microbes–in Household Products, Industrial Products and in Sewage Treatment and Biogas

➢ Microbes in Daily Life

- Microbes are the major components of the biological system on the earth.
- They are very minute organisms that can not be seen with the naked eyes but are viewed under the microscope.
- Microbes are present everywhere such as in soil, water, air, inside our body and bodies of animals and plants.
- They are also present where no other life-form could exist such as deep inside the geysers (thermal vents) where the temperature may be as high as 100°C, deep in the soil, under the layers of snow several metres thick and in highly acidic environments.
- Microbes are diverse–protozoa, bacteria, virus, fungi and microscopic plants.
- Viruses, viroids and also prions are not considered as living entities, even though, they are considered as infectious agents.
- Microbes like bacteria and many fungi can be grown on nutritive media to form colonies, that can be seen with the naked eyes. Such cultures are useful in studies on micro-organisms.
- Some microbes are harmful to mankind, causing several infectious diseases but some are important in many ways for human welfare.

➢ Microbes in household products.

1. *Lactobacillus* or Lactic Acid Bacteria (LAB)

- It converts milk into curd.
- It produces lactic acid that coagulates and partially digests the milk protein casein.
- A small amount of curd containing LAB converts fresh milk into curd.
- It also increases vitamin B_{12}.
- In the stomach, it inhibits the growth of pathogens.

2. Bacterial Fermentation (Anaerobic Respiration)

- The dough which is formed by the fermentative activity of bacteria is used to make foods such as *dosa, idli* etc.
- The puffed-up appearance of dough is due to the production of CO_2 gas.
- 'Toddy' is an alcoholic drink, made by fermenting flower sap from palms by bacteria.
- Microbes are used to ferment fish, soyabean and bamboo-shoots to make foods.
- Microbes are used to produce cheeses differing in flavour, taste and texture *e.g.*, Large holes in 'Swiss cheese' are due to the production of a large amount of CO_2 by *Propionibacterium shermanii* (a bacterium).
- 'Roquefort cheese' is ripened by growing a specific fungus (*Penicillium roqueforti*) on them that gives them a particular flavour.

3. Baker's Yeast (*Saccharomyces cerevisiae*) :

- It is used to make bread by fermenting dough.

➢ Microbes in Industrial Products

- The large scale production of beverages, antibiotics etc., on an industrial scale, requires growing microbes in very large vessels called fermentors or bioreactors.

1. Fermented Beverages

- *Saccharomyces cerevisiae* (Brewer's yeast) is used in the production of beverages by fermenting malted cereals and fruit juices to produce ethanol.
- Wine and Beer are produced without distillation.
- Whisky, Brandy and Rum are produced by distillation of the fermented broth.

2. Antibiotics

- The chemical substances produced by some microbes that can kill or inhibit the growth of other disease-causing microbes.
- They are used to treat plague, whooping cough, diphtheria, leprosy and many other infectious diseases.

➢ **Penicillin**

- First antibiotic discovered by Alexander Fleming in 1929.
- He observed that a mould **(***Penicillium notatum***)** growing in unwashed culture plates around which *Staphylococci* could not grow.
- He extracted penicillin from it.
- Ernest Chain and Howard Florey established its full potential as an effective antibiotic.
- Fleming, Chain and Florey were awarded Nobel Prize (1945).

3. Chemicals, enzymes and other bioactive molecules

(a) Organic Acids : *e.g.*,

- *Aspergillus niger* (a fungus) : Citric acid
- *Acetobacter aceti* (a bacterium) : Acetic acid
- *Clostridium butylicum* (a bacterium) : Butyric acid
- *Lactobacillus* (a bacterium) : Lactic acid

(b) Alcohol :

- Yeast **(***Saccharomyces cerevisiae***)** is used to produce ethanol.

(c) Enzymes :

- **Lipases :** Used in detergent formulations. Help to remove oily stains from the laundry.
- **Pectinases and Proteases :** To clarify bottled juices.
- **Streptokinase :** Produced by *Streptococcus***.** Used as a 'clot buster' to remove clots from the blood vessels of patients who have a myocardial infarction.

(d) Cyclosporin A :

- It is produced by *Trichoderma polysporum* (fungus).
- It is used as an immunosuppressive agent in organ-transplant patients.

(e) Statins :

- It is produced by *Monascus purpureus* (a yeast).
- It is used as a blood-cholesterol lowering agent.
- It inhibits the enzymes responsible for the synthesis of cholesterol.

➢ Microbes in Sewage Treatment

- Sewage (municipal waste-water) contains a large amount of human excreta, organic matter and microbes.
- Sewage is treated in Sewage Treatment Plants (STPs) to make it less polluting. It includes stages namely : primary treatment and secondary treatment.

(a) Primary Treatment

- It is a physical treatment.
- It is the physical removal of large and small particles from sewage. It includes :
  - Removal of floating debris by sequential filtration.
  - Removal of the grit (soil and pebbles) by sedimentation.
  - Removal of solids that settle form the primary sludge and the supernatant forms the primary effluent.
  - The effluent is taken for secondary treatments.

(b) Secondary treatment (Biological treatment)

- Primary effluent is passed into large aeration tanks and constantly agitated.
- This allows vigorous growth of useful aerobic microbes into flocs (masses of bacteria associated with fungal filaments to form mesh-like structures).
- These microbes consume the major part of the organic matter in the effluent.
- This reduces the BOD (Biochemical Oxygen Demand) of the effluent.
- The effluent is then passed into a settling tank where the bacterial 'flocs' are allowed to sediment. This sediment is called 'activated sludge'.
- A small part of the activated sludge is pumped back into the aeration tank to serve as the inoculum.
- The remaining major part of the sludge is pumped into large tanks called **anaerobic sludge digesters.**
- Here, some anaerobic bacteria digest the bacteria and fungi in the sludge by producing gases like CH_4, H_2S and CO_2. These gases form the biogas.

- The effluent from the secondary treatment plant is released into natural water bodies like rivers and streams.
- The Ministry of Environment and Forests has initiated **the Ganga Action Plan** and **Yamuna Action Plan** to save rivers from water pollution.

➢ Biological Oxygen Demand (BOD)

- BOD represents the amount of dissolved oxygen required for the complete oxidation of all the organic matter present in one litre of water by bacteria at 20°C.
- BOD measures the amount of organic matter present in water by measuring the rate of O_2 taken up by microbes.
- Higher BOD indicates that the water is highly polluted by organic matter. A lower value of BOD means the water is less polluted or normal.

➢ Microbes in Production of Biogas

- Biogas is a mixture of inflammable gases (mainly CH_4) produced by the microbial activity.
- Biogas is used for cooking and lighting.
- Methanogens grow anaerobically on cellulosic material and produce CH_4 gas *e.g., Methanobacterium*.
- *Methanobacterium* is found in the anaerobic sludge and rumen of cattle (for cellulose digestion).
- The dung of cattle (gobar) is rich in these bacteria.
- Dung can be used for the generation of biogas (Gobar gas).

➢ A Biogas plant consists of

(a) A concrete tank **(b)** Floating cover **(c)** An outlet

- The concrete tank (10-15 feet deep) collects bio-wastes and slurry of dung.
- A floating cover is placed over the slurry, which keeps on rising as the biogas is produced.
- An outlet which is connected to a pipe to supply biogas.
- An outlet to remove spent slurry (used as fertilizer).

Indian Agricultural Research Institute (IARI), Khadi and Village Industries Commission (KVIC) developed the technology of biogas production in India.

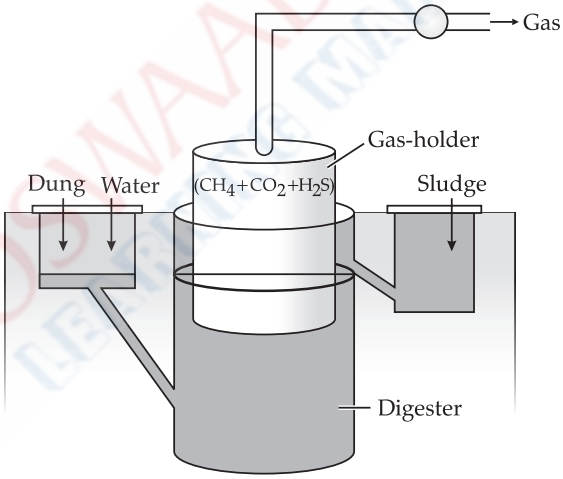

Fig. 2.1 A Biogas plant

Mnemonics

1.

Microbes in Human Welfare

Concept : Organic acid bacteria

Mnemonic : All **A**nswers **Cl**early **La**belled

Interpretation : ***Aspergillus niger, Acetobacter aceti, Clostridium butylicium, Lactobacillus.***

Microbes as Biocontrol Agents and Bio-Fertilizers

➢ Biocontrol

- It is the use of biological methods for controlling plant diseases and pests.

➢ Chemical Pesticides and Insecticides

- These are toxic and harmful to all organisms including human beings and cause pollution.
- Chemical pesticides kills both useful and harmful life forms.
- Weedicides used to eliminate weeds cause soil pollution.

➢ Microbial biocontrol agents

(a) ***Bacillus thuringiensis*** **(Bt) :**

- This is to control the butterfly caterpillar. These are available in sachets as dried spores which are mixed with water and sprayed on vulnerable plants such as *Brassica* and fruit trees, where these are eaten by the insect larvae. In the gut of the larvae, the toxin is released and the larvae get killed. Scientists have introduced *B. thuringiensis* toxin genes into plants *e.g.,* **Bt cotton.**

(b) ***Trichoderma sp.*** **(Fungus) :**

- These are free livings species that are seen in the root ecosystems. They are effective biocontrol agents of several plant pathogens.

(c) ***Baculoviruses*** **(Especially genus *Nucleopolyhedrovirus*) :**

- It attacks insects and other arthropods. These are suitable for species-specific, narrow spectrum insecticidal applications. This is desirable in the IPM program to conserve beneficial insects.

➢ Microbes as Biofertilizers

- Biofertilizers are the micro-organisms that enrich the nutrient quality of the soil. *e.g.,* Bacteria, fungi, cyanobacteria etc.

➢ *Rhizobium*

- It is a symbiotic bacteria found in root nodules of leguminous plants that fixes atmospheric N_2.
- Free-living bacteria in the soil such as *Azospirillum* and *Azotobacter* enrich the nitrogen content of the soil.

➢ Mycorrhiza

- It is a symbiotic association of fungi (*e.g.,* the genus of *Glomus*) with the roots of higher plants.
- The fungus gets food for the plant.
- The fungal symbiont help to absorb phosphorous from soil and passes it to the plant, give resistance to root-borne pathogens, tolerance to salinity and drought and also gives an overall increase in plant growth and development.

➢ Cyanobacteria (Bluegreen algae) :

- They are autotrophic microbes that fixes atmospheric nitrogen *e.g., Anabaena, Nostoc, Oscillatoria* etc.
- In paddy fields, Cyanobacteria serve as an important biofertilizers.
- It also adds organic matter to the soil and increases its fertility.

Mnemonics

1.

Microbes in Human Welfare

Concept : Microbial Biocontrol agents
Mnemonic : Back **T**o **Ba**ck
Interpretation : *Bacillus thuringiensis, Trichoderma sp., Baculoviruses.*

2.

Microbes in Human Welfare

Concept : Free living bacteria
Mnemonic : Almond's **A**pple
Interpretation : *Azospirillum, Azotobacter*

3.

Microbes in Human Welfare

Concept : Cyanobacteria (Blue green algae) example
Mnemonic : After **N**asa's **O**peration
Interpretation : *Anabaena, Nostoc, Oscillatoria*

Know the Terms

- **BOD :** Biochemical oxygen demand
- **KVIC :** Khadi and Village Industries Commission
- **GAP :** Ganga Action Plan
- **LAB :** Lactic acid Bacteria
- **YAP :** Yamuna Action Plan
- **STPs :** Sewage Treatment Plants
- **IPM :** Integrated Pest Management
- **Primary sewage treatment :** It is a mechanical process involving the removal of coarse solid materials.
- **Secondary sewage treatment :** It is a biological process involving the action of microbes.
- **Tertiary sewage treatment :** The treatment removes remaining inorganic compounds and substances, such as the nitrogen and phosphorous.
- **Flocs :** They are masses of bacteria associated with fungal filaments to form mesh-like structures include, tertiary sewage treatment.
- **Biological Oxygen Demand (BOD) :** It is the method of determining the amount of oxygen required by microorganisms to decompose the waste present in the water supply.
- **Biocontrol :** It refers to the use of biological methods for controlling plant diseases and pests.
- **Biopesticides :** The biological agents which are used to control certain weeds, insects and pathogen are called biopesticides.
- **Methanogens :** Microorganisms that produce methane along with CO_2 and H_2 under anaerobic conditions are called methanogens.
- **Biofertilisers :** These are organisms that enrich the nutrient content of the soil.
- **Symbiotic :** The relationship involving interaction between two different organisms living in close physical association.

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UNIT-IX : BIOTECHNOLOGY AND ITS APPLICATIONS

CHAPTER-3

BIOTECHNOLOGY:PRINCIPLES AND PROCESSES

Revision Notes

Principles of Biotechnology and Tools of Recombinant DNA Technology

- **Introduction**
  - **Biotechnology** deals with the techniques of using live organisms or their enzymes for products and processes useful to humans.
  - The term biotechnology was given by Karl Ereky (1919).
  - 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'.
- **Biotechnology deals with :**
  - Microbe-mediated processes (making curd, bread, wine, etc.)
  - *In vitro* fertilisation ('test-tube' baby programme).
  - Synthesis and uses of a gene.
  - Preparation of vaccine.
  - Correction of a defective gene.
- **Principles of Biotechnology**
  - **The two core techniques of modern biotechnology are :**
    - **(a) Genetic engineering :** The technique in which the genetic material (DNA and RNA) is chemically altered and introduced into host organisms to change the phenotype is known as genetic engineering.
    - **(b) Maintenance of sterile ambience :** It is necessary for chemical engineering processes to grow only the desired microbe / eukaryotic cell in large quantities for the manufacture of antibiotics, vaccines, enzymes, etc.

- Traditional hybridisation techniques lead to the inclusion and multiplication of undesirable genes along with desired genes.
- Genetic engineering helps to isolate and introduce only desirable genes into the target organism.
- A piece of DNA is not only 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.
- First recombinant DNA was emerged from the possibility of linking a gene of antibiotic resistance with a native plasmid of *Salmonella typhimurium*. The plasmid is an autonomously replicating circular extra-chromosomal DNA.
- Stanley Cohen and Herbert Boyer (1972) constructed the first recombinant DNA. They isolated the antibiotic resistance gene by cutting out a piece of DNA from a plasmid.

➢ Steps in Genetically Modifying an Organism

- **There are three basic steps 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

1. Restriction Enzymes ('molecular scissors')

- The restriction enzymes are called molecular scissors and are responsible for cutting DNA.
- In 1963, two enzymes responsible for restricting the growth of bacteriophage in *E. coli* were isolated. One of these added methyl groups to DNA. The other (restriction endonuclease) cut the DNA.
- The first restriction endonuclease is Hind II. Isolated by Smith, Wilcox and Kelley (1968) from *Haemophilus influenzae* bacteria. It always cuts DNA molecules at a particular point by recognizing a specific sequence of six base pairs. This is known as the recognition sequence for Hind II.
- Today more than 900 restriction enzymes have been isolated from over 230 strains of bacteria.

➢ 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 *e.g.*, *EcoRI* comes from *E. coli* RY 13, where R = the strain, Roman numbers = the order in which the enzymes were isolated from that strain of bacteria.
- Restriction enzymes belong to a class of enzymes called **nucleases**.
- The nucleases include **exonucleases** and **endonucleases**.

(i) Exonucleases

They remove nucleotides from the ends of the DNA.

(ii) Endonucleases

- They cut at specific positions within the DNA.
- Each restriction endonuclease can bind to a 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 sequence in the DNA.
- The palindrome in DNA is a sequence of base pairs that read the same on the two strands in the 5′ → 3′ direction and in 3′ → 5′ direction. *e.g.*,

  5′ —— GAATTC —— 3′

  3′ —— CTTAAG —— 5′
- 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 overhanging stretches at the ends. They are called sticky ends.
- They form H-bonds with their complementary cut counterparts. This stickiness facilitates the action 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 the enzyme DNA ligases.

➢ Separation and isolation of DNA fragments :

- DNA fragments formed by restriction endonuclease can be separated by a technique called **Gel electrophoresis**.
- DNA fragments are negatively charged. So, they can be separated by moving them towards the anode under the influence of an electric field through a medium / matrix such as **agarose** (which is a natural polymer of D-galactose and 3, 6 anhydro L-galactose and is extracted from seaweeds).
- The DNA fragments separate (resolve) according to their size through the sieving effect provided by the agarose gel.

- The smaller sized fragments 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 the gel piece. This step is called **elution**.
- These purified DNA fragments are used in constructing recombinant DNA by joining them with cloning vectors.

2. Cloning Vectors

- These are the DNA molecules that can carry a foreign DNA segment and replicate inside the host cells e.g., **plasmids** (circular extra-chromosomal DNA of bacteria) and **bacteriophages**.
- Bacteriophages (high number per cell) 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 is also multiplied to the numbers equal to the copy number of the vectors.

➢ Features of cloning vector :

(a) Origin of replication (*ori*)

- This is a DNA sequence from where replication starts. A piece of DNA linked to *ori* site can replicate within the host cells. This also controls the copy number of the linked DNA. So, to get many copies of the target DNA, it should be cloned in a vector whose origin support 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 non transformant *E. coli* cells do 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 site 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 BamHI site of the tetracycline resistance gene in the vector pBR322.
- 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 to a **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 the insertion of alien DNA and helps in the selection of recombinants.
- Selection of recombinants due to the inactivation of antibiotics requires simultaneous plating on two plates having different antibiotics.
- Therefore, alternative selectable markers have developed to differentiate recombinants from non-recombinants based on 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. So, the enzyme is inactivated. It is called **insertional inactivation**. Such colonies do not produce any colour. These are identified as recombinant colonies.
- If the plasmid in bacteria do not have any insert it gives blue coloured colonies in presence of chromogenic substrate.

(d) Vectors for cloning genes in plants and animals

- Genetic tools of some pathogens can be transformed into useful vectors for delivering genes to plants and animals. e.g., *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 can use the mechanisms to deliver genes of interest into plants.
- Retroviruses in animals can transform normal cells into **cancerous** cells. So, they are used to deliver desirable genes into animal cells.

3. **Competent Host (For Transformation with Recombinant DNA)**
   - Competent cells are capable of uptaking DNA from the surrounding. For the process of transformation, bacterial cells are made competent, so that DNA can enter the cells.
   - DNA is a hydrophilic molecule. So it cannot pass through cell membranes.
   - To avoid this problem, bacterial cells are treated with a specific concentration of a divalent cations (*e.g.*, calcium), so as to increase the pore size in the cell wall.
   - So, DNA enters the bacterium through pores in the cell wall. Such cells are incubated with recombinant DNA on ice.
   - They are placed briefly at 42°C (heat shock) and then back on ice. This enables the bacteria to take up the recombinant DNA.

➢ **Other methods to introduce alien DNA into host cells :**

(a) Micro-injection : In this, recombinant DNA is directly injected into the nucleus of an animal cell.

(b) Biolistics (gene gun) method : In this, 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 : These vectors, when infect the cell, transfer the recombinant DNA into the host.

IMPORTANT DIAGRAMS :

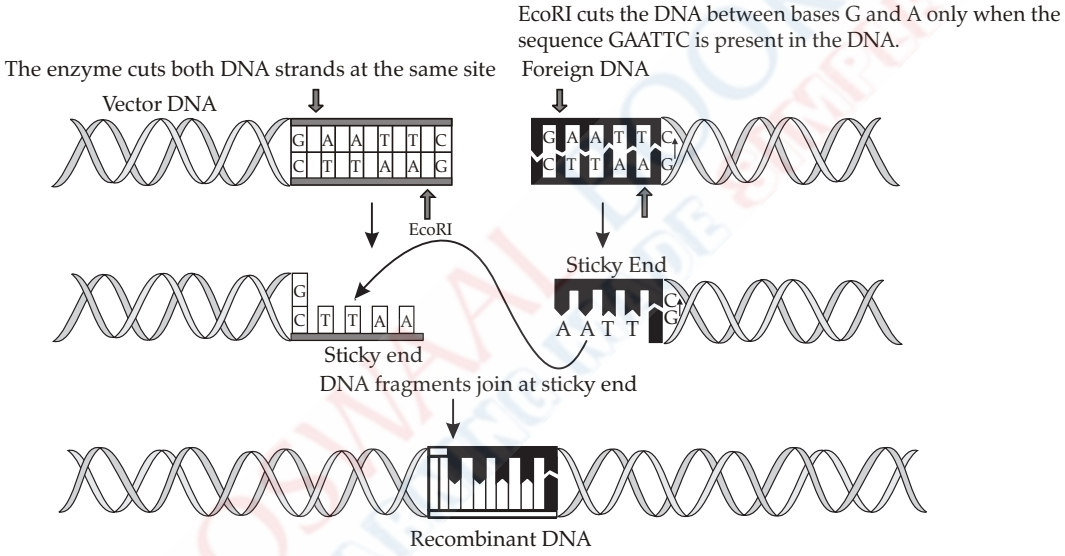

Fig 3.1 : Steps in formation of recombinant DNA by action of restriction endonuclease enzyme- EcoRI.

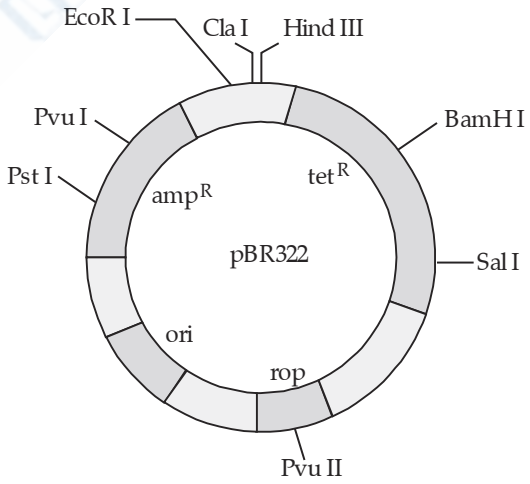

Fig 3.2 : Cloning vector pBR322

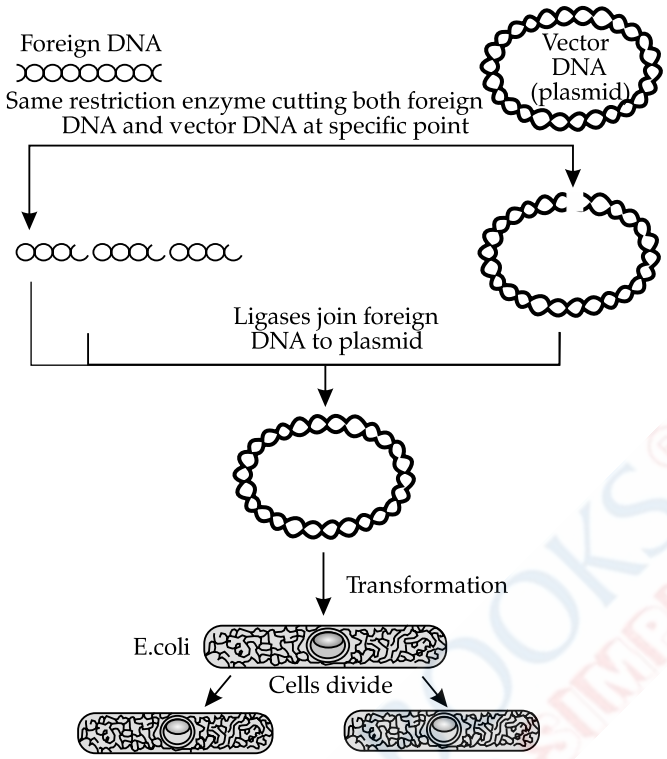

Fig 3.3 : Diagrammatic representation of recombinant DNA technology

Mnemonics

1.

Biotechnology : Principles and Processes

Concept : Important tools in Biotechnology.

Mnemonic : HELina Gyi Gaate Gate : Speed of 40 Hilte-dulte Gun Gunaate by Road Highway

Interpretation : Tools		**Characters**
Heat Shock	:	**Sudden temperature raised to 40°C**
Electroporation	:	**High voltage pulse**
Liposomes	:	**Genes to cells in vivo**
Gene gun	:	**Gold particles**
Genetic marker	:	**R plasmid**
Gene synthesis	:	**Hormone somatostatin**

2.

Biotechnology : Principles and Processes

Concept : Animal Clones

Mnemonic : Never Decide Naming	:	**People with Strong Attitude**
Interpretation : Clone name	:	**Species**
Noori	:	**Pashmina Goat**
Dolly	:	**Sheep**
Noah	:	**Asian Gaur**

Process of Recombinant DNA Technology

1. Isolation of the Genetic Material (DNA)

- To get pure DNA (free from other macro-molecules), 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 (RNA, proteins, polysaccharides and lipids).
- Genes (DNA) are interwined 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.
- When chilled ethanol is added, purified DNA precipitates out as a collection of fine threads in the suspension.

2. Cutting of DNA at Specific Locations

- Restriction enzyme digestions are performed by incubating purified DNA with the restriction enzyme, at the optimal conditions. After cutting, the source DNA and vector DNA segments are ligated to form recombinant DNA.

3. Isolation of derived DNA fragments.

- **Agarose gel electrophoresis** is employed to check the progression of a restriction enzyme digestion. As DNA is negatively charged, it moves towards the anode. The process is repeated with the vector DNA also.

4. 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**.
- The technique was developed by *Kary Mullis* in 1985 and for this, he was awarded the Nobel Prize in 1993.
- Primers are small chemically synthesized oligonucleotides that are complementary to the regions of DNA.
- The enzyme DNA polymerase extends the primers using the nucleotides and the genomic DNA (template).
- For amplification, a thermostable DNA polymerase (isolated from a Thermophilic bacterium, *Thermus aquaticus*) is used.
- It remains active at high temperature during the denaturation of double-stranded DNA.
- Source DNA and vector DNA are cut with the same endonuclease so as to obtain the sticky ends.
- These are then ligated by mixing the gene of interest vector DNA in presence of the enzyme DNA ligase to form recombinant DNA.
- The amplified fragment can be used to ligate with a vector for further cloning.

5. Insertion of Recombinant DNA into the Host Cell / organism

- There are several methods of introducing the ligated DNA into recipient cells as described earlier.
- Recipient cells take up DNA present in its surrounding.

6. Isolation of Recombinant Cell

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

7. Obtaining the Foreign Gene Product

- The ultimate aim of recombinant DNA technology is to produce a desirable protein or product.
- The foreign gene gets expressed 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 purified using different separation techniques.
- The cells can also be multiplied on large scale in a continuous culture system.
- Here, the used medium is drained out from one side while the fresh medium is added from the other side.
- It maintains the cells more physiologically active and so produces a larger biomass leading to higher yields of the desired protein.

8. Downstream Processing : All the processes to which the product is subjected to before being marketed as a final and finished product are called as downstream processing.

- It includes 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 through clinical trials as in the 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.

➢ Bioreactors

- To produce large quantities of products, the bioreactors are used where large volumes (100-1000 litres) of culture can be processed.
- 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 (temperature, pH, substrate, salts, vitamins, oxygen) for achieving the desired product.
- There are two types of bioreactors namely,
  - **(a)** Simple stirred-tank bioreactor
  - **(b)** Sparged stirred-tank bioreactor
- The most commonly used bioreactors are of stirring type.

➢ Stirred-tank Reactor

- It is usually cylindrical or with a curved base to facilitate the proper mixing of the reacting contents.
- The stirrer facilitates even mixing and oxygen availability throughout the bioreactor.
- 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).

IMPORTANT DIAGRAMS :

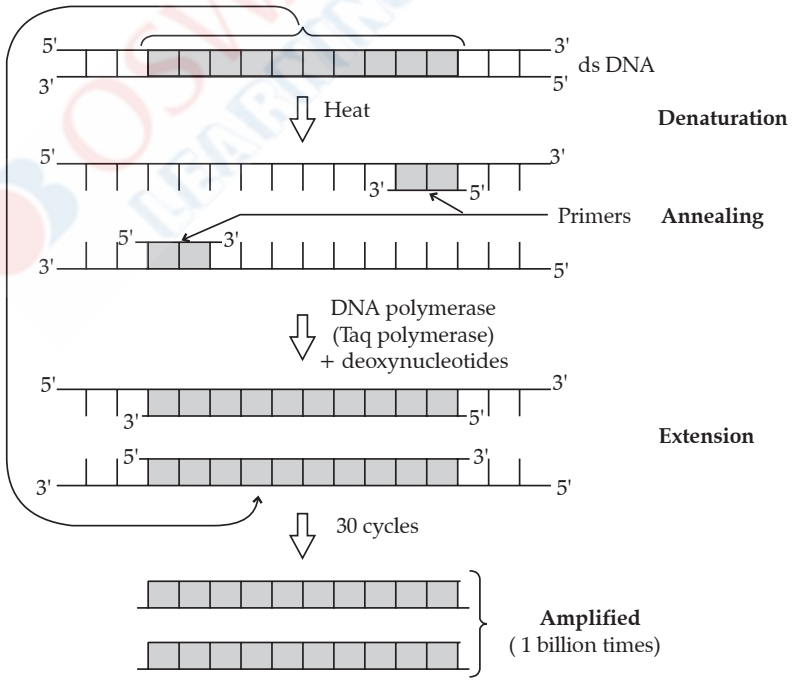

Fig 3.4 : Polymerase Chain reaction

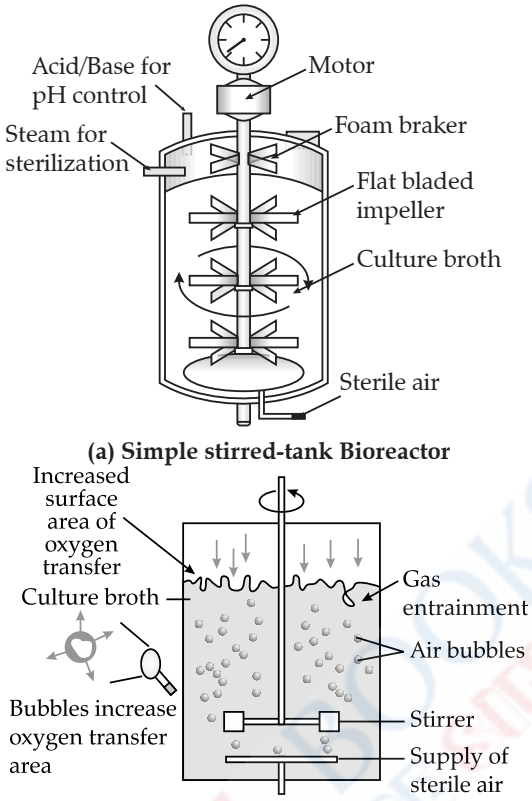

Fig 3.5 : Bioreactors- (a) Simple stirred-tank Bioreactor, (b) Sparged stirred-tank bioreactor

Know the Terms

- **Genetic engineering :** Techniques to alter the gene or chemistry of genetic material (DNA and RNA), to introduce these into host organisms and thus change the phenotype of the host organism.
- **Restriction enzymes :** Enzymes that are used to cut DNA segment at a specific site are called restriction enzymes.
- **Exonucleases :** Remove nucleotides from the ends of the DNA molecule.
- **Endonucleases :** Make cuts at specific positions within the DNA molecule.
- **Plasmid :** Autonomously replicating circular extra-chromosomal DNA of any bacteria.
- **Origin of replication :** A specific DNA sequence that is responsible for initiating replication is called the origin of replication.
- **Vectors :** These are plasmid DNA or viruses that act as a vehicle to transfer the piece of DNA attached to it.
- **Palindromic Nucleotide Sequences :** The palindrome in DNA is a sequence of base pairs that reads the same on the two strands when the orientation of reading is kept the same.
- **Gel electrophoresis :** A technique that is used to separate the fragments of DNA is known as gel electrophoresis.
- **Transformation :** It is a procedure through which a piece of DNA is introduced in a host bacterium.
- **Insertional inactivation :** The procedure of inserting a recombinant DNA within coding sequence of a functional gene that makes this gene inactive (unable to express) is called insertional inactivation.
- **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.
- **Micro-injection :** A technique in which recombinant DNA is directly injected into the nucleus of an animal's cell.
- **Biolistics or Gene gun :** Plant cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA in a method known as biolistics or gene gun.
- **Bioreactors :** Bioreactors are vessels in which raw materials are biologically converted into specific products, enzymes etc., using microbial plants, animal or human cells.

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UNIT-IX : BIOTECHNOLOGY AND ITS APPLICATIONS

CHAPTER-4

BIOTECHNOLOGY AND ITS APPLICATIONS

Revision Notes

Application of Biotechnology in Agriculture and Medicine

➢ Applications of Biotechnology

- Biotechnology essentially deals with industrial-scale production of biopharmaceuticals using genetically modified microbes, fungi, plants and animals.
- The applications of biotechnology include therapeutics, diagnostics, and genetically modified crops for agriculture, processed food, bioremediation, waste treatment and energy production.
- **Three critical research areas of biotechnology are :**
  (a) Providing the best catalyst in the form of an improved organism usually a microbe or pure enzyme.
  (b) Creating optimal conditions through engineering for a catalyst to act.
  (c) Downstream processing technologies to purify the protein / organic compound.

➢ Biotechnological Applications in Agriculture

- **Three options for increasing food production are :**
  (a) Agro-chemical based agriculture.
  (b) Organic agriculture.
  (c) Genetically engineered crop-based agriculture.
- The Green Revolution succeeded in tripling the food supply.
- Increased yields have partly been due to the use of improved crop varieties, but mainly due to the use of better management practices and use of agrochemicals (fertilisers and pesticides).
- Genetically Modified Organisms (GMO) or transgenic organisms are the plants, bacteria, fungi and 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) It helps to reduce post-harvest losses.
(c) It increases the efficiency of mineral usage by plants (this prevents early exhaustion of fertility of soil).
(d) It enhances the nutritional value of food *e.g.*, Vitamin 'A' enriched rice.
(e) GM is used to create tailor-made plants to supply alternative resources to industries in the form of starches, fuels and pharmaceuticals.

➢ Pest Resistant Plants

- Pest Resistant Plants reduce the use of chemical pesticide.
- It reduces the need for insecticides *e.g.*, Bt cotton, Bt corn, rice, tomato, potato, soyabean, etc.

➢ Bt Cotton

- Some strains of *Bacillus thuringiensis* produce proteins that kill insects like coleopterans (beetles), lepidopterans (tobacco, budworm, armyworm) and dipterans (flies, mosquitoes).
- *B. thuringiensis* forms a toxic insecticidal protein (Bt toxin) crystal during a particular phase of their growth. It does not kill the *Bacillus* as it exists as inactive protoxins.
- When an insect ingests the inactive toxin, it is converted into an active toxin due to the alkaline pH of the gut which solubilises the crystals.
- The toxin binds to the surface of midgut epithelial cells and create pores.
- It causes cells to swell and undergo lysis and ultimately leading to 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 and that of *cryI Ab* controls corn borer.

➢ Nematode resistance in tobacco plant

- A *Meloidogyne 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 defence in all eukaryotic organisms.
- It prevents translation of a specific mRNA (silencing) due to a complementary dsRNA molecule.
- The source of this complementary RNA is from an infection by RNA viruses 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 produces both sense and anti-sense RNA in host cells.
- These two RNA's being complementary to each other form a double-stranded RNA (dsRNA) that initiated RNAi and thus, silenced the specific mRNA of nematode.
- Thus, the parasite cannot survive in a transgenic host expressing specific interfering RNA.

➢ Biotechnological Applications 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 is common in the case of similar products isolated from non-human sources.
- At present, about 30 recombinant therapeutics have been approved for human use in the world including India.
- In India, 12 of these are presently being marketed.

➢ Genetically Engineered Insulin

- The 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 from the pancreas of animals (cattle and pigs) causes allergy or other types of reactions to the foreign protein.
- Insulin consists of two short polypeptide chains (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 mature and functional hormone.
- The pro-hormone contains an extra stretch called the C peptide.
- This 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.
- The chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin.

➢ Stem Cell Technology :

- Stem cells are undifferentiated or "blank" cells.
- They are special human cells which are capable to develop into many different cell types.
- This can range from muscle cells to brain cells. In some cases,they can also fix damage tissues.
- Stem cells can be obtained from an embryo, or by using a specialized body cells (developed by a technique) which behave like embryonic stem cells. These cells are known as induced pluripotent stem cells (IPS cells).
- They are used in treating several clinical problems like : (i) Tissue regeneration. (ii) Damaged myocardium after heart infraction. (iii) Brain after stroke. (iv) Spinal cord after mechanical injury.
- Advantages of stem cells technology :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.The regenerative property of stem cell can be used in replacing any organ which is not working or damaged. It can help in studying human growth and cell development. It can be used to test the effects of medicinal drugs and medicine without the use of animals.

➢ Gene Therapy :

- It is a method to correct a gene defect diagnosed in a child / embryo.
- Here, genes are inserted into a person's cells and tissues to treat a hereditary disease.
- It compensates for the non-functional gene.
- First clinical gene therapy was given in 1990 to a four year old girl with adenosine deaminase (ADA) deficiency.
- This 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 (injection of functional ADA) but these approaches are not completely curative.
- In gene therapy, lymphocytes from the patient's blood are grown in a culture.
- Then, a functional ADA cDNA(using a retroviral vector) is introduced into these lymphocytes.
- They are then returned to the patient.

- This should be periodically repeated as these cells are not immortal.
- However, if the ADA gene (from bone marrow cells) is introduced into cells at the early embryonic stages, it could be a permanent cure.

➢ Molecular Diagnosis

- Recombinant DNA technology, PCR and Enzyme Linked Immuno-sorbent Assay (ELISA) are some techniques for early diagnosis.
- The presence of a pathogen is normally suspected only when the pathogen has produced a symptom.
- By this time, the concentration of the pathogen will be already very high in the body.
- However, a 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 other 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.

IMPORTANT DIAGRAMS :

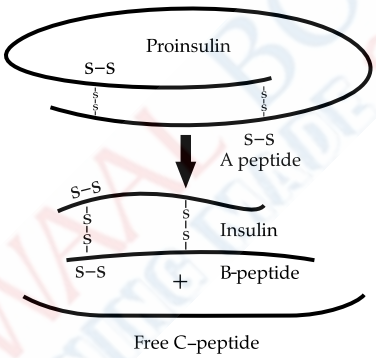

Fig 4.1 : Genetically Engineered Insulin

Mnemonics

1.

Biotechnology and its Applications

Concept : Achievement through transgenic crops or GM crops.

Mnemonic : Proper **P**ackage of **M**uscular **B**ody : **H**ardwork **C**an **T**ransform

Interpretation :

Achievements of	:	Example
Protein of interest	:	Hirudin
Production of desired genotype	:	Cry protein (Crystal protein)
Modification of existing Biosynthetic pathway	:	Transgenic rice (higher content of vitamin A)

Transgenic Animals and Bioethical Issues

➢ Transgenic Animals

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

➢ Advantages or Benefits of Transgenic Animals

- **To study normal physiology and development :**
  - **(a)** Transgenic animals are used to study how genes are regulated and how they affect the normal body functions and their development.
  - **(b)** *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.
- **To Study the contribution of genes in the development of a disease :**
  - **(a)** Transgenic models help for the investigation of new treatments for human diseases.
  - **(b)** *E.g.,* transgenic models for many human diseases such as cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's disease.
- **Biological products :**
  - **(a)** Some medicines contain biological products, but they are often expensive.
  - **(b)** Transgenic animals are used to produce useful biological products by introducing genes that codes for a particular product. *E.g.*, human protein (α-1-antitrypsin) used to treat emphysema, products for the treatment of phenylketonuria (PKU) and cystic fibrosis etc.
  - **(c)** In 1997, *Rosie* (first transgenic cow) produced human protein-enriched milk (2.4 gm per litre).
  - **(d)** It contains the human alpha-lactalbumin and is a nutritionally more balanced product for human babies than natural cow-milk.
- **Vaccine safety testing :** Transgenic mice are being developed and used in testing the safety of vaccines before they are used for humans. The polio vaccine was tested in mice.
- **Chemical safety testing (toxicity testing) :** Transgenic animals are made to know the effect of toxic chemicals. This is also known as toxicity / safety testing.

➢ Ethical Issues

- **Problem of unpredictable results**
  - **(a)** Genetic modification may cause unpredictable results when such organisms are introduced into the ecosystem.
  - **(b)** Therefore, the Indian Government has set up organizations like **GEAC** (Genetic Engineering Approval Committee), which makes decisions about the validity of GM research and the safety of GM-organisms for public services.
- **Problems of patent**
  - **(a)** 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 country.
  - **(b)** *E.g.,* Basmati rice, herbal medicines like turmeric, neem, etc.
  - **(c)** Basmati rice has a unique aroma and flavour.
  - **(d)** India has 27 varieties of Basmati.
  - **(e)** In 1997, an American company got patent rights on Basmati rice through the US Patent and Trademark Office.
  - **(f)** This allowed the company to sell a 'new' variety of Basmati which had actually been derived from Indian farmer's varieties.
  - **(g)** Indian Basmati was crossed with semi-dwarf varieties and claimed as a novelty.
  - **(h)** Other people selling Basmati rice could be restricted by the patent.
- **Biopiracy :**
  - **(a)** It is the use of bio-resources by multinational companies and other organizations without proper authorization from the countries and people concerned.
  - **(b)** Most of the industrialized nations are poor in biodiversity and traditional knowledge.
  - **(c)** The developing and the underdeveloped world have rich biodiversity and traditional knowledge related to bio-resources.
  - **(d)** It has to develop laws to prevent unauthorized exploitation of bio-resources and traditional knowledge.
  - **(e)** Indian Parliament has cleared the second amendment of the Indian Patents Bill that considers such issues, including patent terms, emergency provisions and research and development initiative.

Know the Terms

- **ELISA :** Enzyme-linked Immunosorbent Assay.
- **GEAC :** Genetic Engineering Approval Committee.
- **ADA :** Adenosine deaminase deficiency. This enzyme is crucial for the functioning of the immune system.

- **Probe :** A probe is a piece of single-stranded DNA that is tagged with a radioactive molecule.
- **Vaccines :** It is a liquid containing a dead or attenuated pathogen or it is an antigen that provides temporary or permanent immunity to a disease.
- **Transgenic animals :** Animals that have their DNA manipulated to possess and express an extra or a foreign gene are known as transgenic animals.
- **Biopatent :** A patent is a 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 biological resources or bioresources of other nations, without proper authorization from the countries concerned. This is called biopiracy.
- **SCID :** Severe Combined Immuno-deficiency. It is caused by a defect in the gene for the enzyme adenosine deaminase (ADA).
- **GMO :** Genetically modified organisms.
- **Stem cells :** They are unique human cells that can differentiate into a variety of cell types, ranging from muscle cells to brain cells.
- **Stem cell banking :** It is the extraction, processing and storage of stem cells, so that they may be used for treatment in the future, when required.

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UNIT-X : ECOLOGY AND ENVIRONMENT

CHAPTER-5
ORGANISMS AND POPULATIONS

Revision Notes

Organism and its Environment

- **Environment and its effect on an organism**
  - **Ecology :** It is the branch of biology that deals with the inter-relationship amongst the organisms and their environment. The study of ecology is important to strike a balance between development and maintenance of natural environmental and biotic communities, use and conservation of resources, solve local, regional and global environmental problems.
  - **Environment :** The sum total of all biotic and abiotic factors, substances and conditions that surround and potentially influence organisms without becoming their constituent part is called environment.
  - **Organism and its Environment :** At the organism level, physiological ecology tries to understand how different organisms are adapted to their environment in terms of survival and reproduction. The variation in the intensity and duration of temperature along with annual variations in precipitation results in the formation of major biomes like the desert, rain forest and tundra.
  - Regional and local variations within each biome lead to the formation of different kinds of habitats like tropical rain forest, deciduous forest, desert, sea coast, etc.
  - The habitat includes biotic components like pathogens, parasites, predators and competitors of the organism with which they interact constantly.
  - **Major Abiotic Factors**
    - **(a) Temperature :** It is the most important ecological factor to determine the bio-mass of a place. The average temperature on land varies seasonally and decreases progressively from the equator towards the poles and from plains to mountain tops. Temperature affects the kinetics of enzymes and basal metabolism along with physiological functions of the organisms. The organisms that can tolerate a wide range of temperature are called **eurythermal** and those organisms restricted to a narrow range of temperatures are called **stenothermal.**

(b) Water : Life on earth is unsustainable without water. The productivity and distribution of plants are heavily dependent on water. Some organisms which are tolerant to a wide range of salinities are called **euryhaline** and others that are restricted to a narrow range are called **stenohaline.** Freshwater animals cannot live for long in sea water because of the osmotic problems they would face.

(c) Light : Plants produce food through photosynthesis in presence of sunlight. Some plants are adapted to low light conditions because they are overshadowed by tall canopied trees. Flowering in some plants occurs only in presence of critical daylight called **photoperiodism**. The availability of light and land is closely linked to that of temperature as the sun is the source of both. UV component of sunlight is harmful to plants and animals.

(d) Soil : Types of soil depends upon climate, weathering process or sedimentary and how soil development occurred. Soil composition, grain size and aggregation determine the percolation and water holding capacity of the soils along with pH, mineral composition and topography determine the vegetation in any area.

- **Responses to Abiotic Factor :** In the course of evolution, many species have evolved a constant internal environment to permit all biochemical reactions and physiological functions to work with maximum efficiency to have the overall fitness of species. Organisms try to maintain the constancy of its internal environment (homeostasis) in spite of varying external environment. There are various ways to establish homeostasis :

(i) Regulate : Certain animals can maintain a constant temperature and constant osmolarity to keep up their homeostasis *e.g.*, All birds and mammals, very few lower vertebrates and invertebrates.

Thermoregulation and osmoregulation is the source of success of these organisms in all the environmental conditions. In summers, thermoregulation through sweating reduces the body temperature.

(ii) Conform : In most of animals and plants, their body temperature changes with ambient temperature. Such animals are called conformers. For example, in aquatic animals osmotic concentration of the body fluid changes with that of the ambient water osmotic concentration. Conformers are not able to bear the energetic expenses to maintain the constant body temperature. Heat loss or heat gain is the surface phenomenon. The conformers have more surface area in comparison to their volume.

(iii) Migrate : Many animals, particularly birds move away temporarily from stressful habitat to a more hospitable area and return when the stressful condition is over. For example, *Siberian birds migrate to Keoladeo National park, Bharatpur, India.*

(iv) Suspend : In microorganisms like bacteria, fungi and lower plants, a thick-walled spores are formed which helps them to survive unfavourable conditions. Spores germinate when conditions are favourable. In higher plants, seeds and some other vegetative reproductive structures serves to tide over periods of stress. They reduce their metabolic activity and go into a state of dormancy. They germinate under favourable moisture and temperature.

(v) Adaptation is the attribute of an organism's morphological, physiological and behavioural changes that enables the organisms to survive and reproduce in its habitat. For example, Kangaroo rat fulfil its water requirement by internal oxidation of fat in the absence of water. Thick cuticle in many plants also prevents loss of water. CAM plants open their stomata during night to reduce the loss of water during photosynthesis.

➢ Adaptation of Mammals :

(a) Mammals from colder climates have shorter ears and limbs to minimize heat loss. This is called **Allen's Rule.**

(b) In polar seas aquatic mammals like seals have a thick layer of fat called **blubber,** below their skin that acts as an insulator and reduces loss of body heat.

➢ Physiological and biochemical adaptations :

(a) Altitude sickness is observed at a higher altitude that includes symptoms like nausea, fatigue, heart palpitations due to less oxygen and atmospheric pressure. The person gradually gets acclimatized and stop experiencing altitude sickness. This is a type of physiological adaptation.

(b) Many marine invertebrate and fish live in temperature always less than zero and some lives deep inside the ocean where pressure is very high by an array of biochemical adaptations.

➢ Behavioural adaptation :

(a) Some organisms like desert lizard lack the physiological ability that mammals have, but deal with the high temperature of their habitat by behavioural means. They bask in the sun and absorb heat when their body temperature is low, but move into the shade when the ambient temperature starts increasing.

IMPORTANT DIAGRAMS :

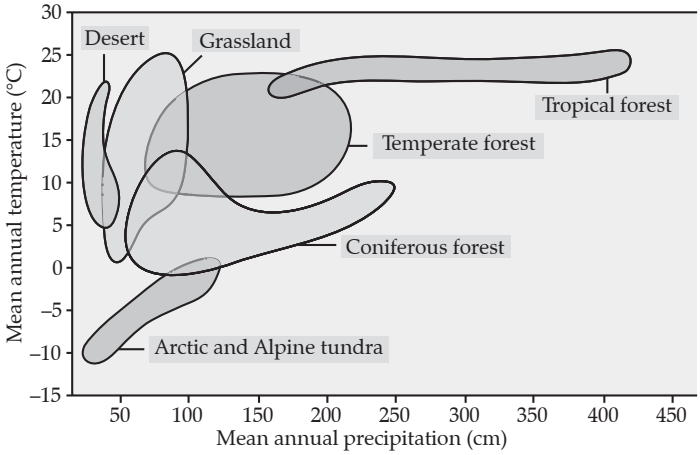

Fig 5.1 : Biome distribution with respect to annual temperature and precipitation.

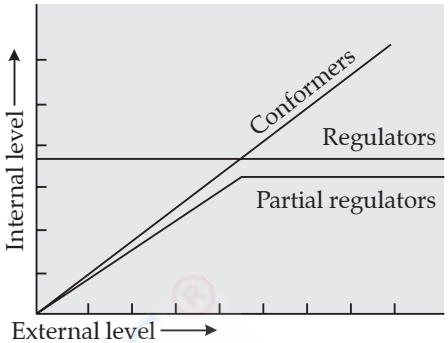

Fig 5.2 : Diagrammatic representation of organismic response

Mnemonics

1.

Organisms and Populations

Concept : Various ways to establish homeostasis
Mnemonic : Right to Confirm My Solo Appearance
Interpretation : Regulate, Conform, Migrate, Suspend, Adaptation

2.

Organisms and Populations

Concept : Major Abiotic factors
Mnemonic : TwinkLing Stars
Interpretation : Temperature, Water, Light, Soil

3.

Organisms and Populations

Concept : Population growth
Mnemonic : No More Invalid Entry
Interpretation : Natality, Mortality, Immigration, Emigration

Population and Population Interactions

➢ Characteristics of Population

- **Populations :** A population is defined as a group of individuals of the same species that live in a particular geographical area at a particular time and functioning as a unit.
- A population has certain attributes that an individual organism does not have. For example, individuals may have births and deaths, but a population has birth rates and death rates.
- **The birth and death rates** are referred to as per capita births or deaths respectively, which increases and decreases with respect to members of the population.
- **Sex ratio** is another attributes of the population. An individual may be male or female but the population has a sex ratio.

- A population at a given time is composed of different individuals of different ages. If the age distribution is plotted for the population, the resulting structure is called age pyramids. The shape of pyramids reflects the shape of the growth status of a population.
- **Population size or population density** (N) is measured in terms of number.
- **Population Growth :** The size of the population is not static. It keeps changing with time, depending upon food availability, predation pressure and adverse weather. The main factors that determine population growth are :
  - **(i)** Natality (number of births) [B]
  - **(ii)** Mortality (number of deaths) [D]
  - **(iii)** Immigration (individuals that come into habitat) [I]
  - **(iv)** Emigration (individual that leaves the habitat) [E]

➢ Differences between Natality Rate and Mortality Rate :

S. No.	Natality Rate	Mortality Rate
1.	Addition of new individuals due to birth, hatching, germination or division.	Number of individuals in a population decreases with the death of the individuals.
2.	Natality shows the number of offsprings produced per unit time per unit population.	Population density and its size is decreased by death rate.

If 'N' is population density at time '*t*', then its density at $t + 1$ is

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

➢ **Growth model :** Growth of population takes place according to the availability of food, habitat condition and presence of other biotic and abiotic factors. There are two main types of models :

(i) **Exponential Growth :** This kind of growth occurs when food and space are available in a sufficient amount. The population grows exponentially or geometrically. If the size of a population is N, the birth rate is represented as '*b*' and death rate as '*d*', then increase and decrease in N during a unit period time '*t*' will be

$$dN/dt = (b - d) \times N$$

Let, $(b - d) = r$.

Then, $dN/dt = rN$

The *r* in this equation is called 'intrinsic rate of natural increase'.

(ii) **Logistic Growth :** There is a competition between the individuals of a population for food and space. The 'fittest' organism survives and reproduces. This type of growth initially shows a lag phase followed by phases of acceleration and de-acceleration. K indicates the carrying capacity of the population.

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

Where N = Population density at time t
r = Intrinsic rate of natural increase
h = Carrying capacity

➢ **Population interaction :** All animals, plants and microbes in a biological community interact with each other. These interactions may be beneficial, detrimental or neutral to one species or both.

The following types of interactions are seen :

(a) **Predation :** It is the interaction between two species members in which the members of one species capture, kill and eat up the members of other species.

(b) **Parasitism :** It is the relationship between two living organisms of different species in which one organism called a parasite obtains its food directly from another living organism called the host.

(c) **Amensalism :** It is the interaction between two living individuals of different species in which one organism is harmed, while the other is neither named nor benefitted.

(d) **Commensalism :** It is the relationship between two living individuals of different species in which one is benefitted, while the other is neither harmed nor benefitted.

(e) **Proto-cooperation :** It is the interaction between two living organisms of different species in which both are mutually benefitted but they can live without each other.

(f) **Competition :** It is the rivalry between two or more organisms for obtaining the same resources.

(g) **Mutualism :** It is the interaction between two organisms of different species where both the partners are benefitted but cannot live separately.

IMPORTANT DIAGRAMS :

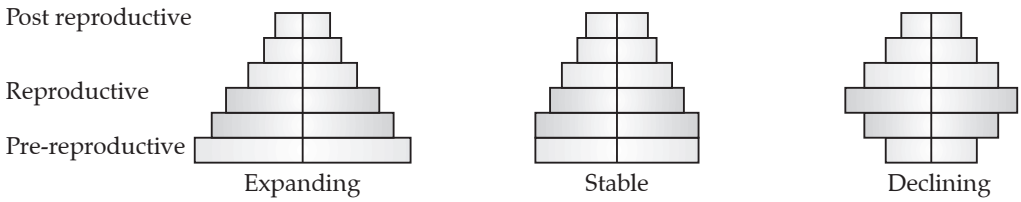

Fig 5.3 : Representation of age pyramids for human population

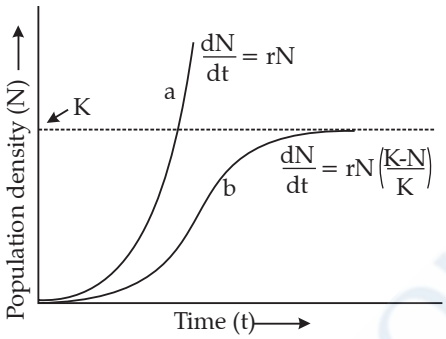

Fig 5.4 : Population Growth Curve :

(a) When responses are not limiting the growth, plot is exponential.

(b) When responses are limiting the growth, plot is logistic. It produces sigmoid curve (S-shaped). K is carrying capacity.

Mnemonics

1.

Organisms and Populations

Concept : Population Density at time t + 1

Mnemonic : Never try Before I Die to Exit

Interpretation : $N_{t+1} = N_t + [(B + 1) - (D + E)]$

Know the Terms

- **Adaptations :** These are certain characteristics that organism develop to survive and reproduce better in their habitat.
- **Aestivation :** It is the process of spending the dry hot periods or summers in an inactive or dormant state to escape in time.
- **Ecotone :** It is a transition zone between two communities.
- **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.
- **Habitat :** The place where an organism lives is called its habitat.
- **Biosphere :** It is composed of all living organisms present on earth which interact with their physical environment.
- **Carrying Capacity :** It is the maximum number of individuals of a population that can be sustained by a given habitat.
- **Population :** It is defined as a group of individuals of the same species that live in a particular geographical area at a particular time and functioning as a unit.
- **Birth rate (Natality) :** It is the ratio of live births in an area to the population of an area.
- **Death rate (Mortality) :** It is the ratio of deaths in an area to the population of an area.
- **Sex ratio :** It is the number of males or females per thousand individuals.
- **Population density :** It is defined as the number of individuals of a population present per unit area at a given time.
- **Natality (B) :** It is the number of births during a given period in a population.

- **Mortality (D) :** It is the number of deaths in a population during a given period.
- **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.
- **Emigration (E) :** It is the number of individuals of the population who left the habitat and gone elsewhere during a given time period.
- **Mutualism :** Both the species are benefitted.
- **Competition :** Both the species are harmed.
- **Parasitism :** One species (parasite) is benefitted and another species (host) is harmed.
- P**redation :** One species (predator) is benefitted and another species (prey) is harmed.
- **Commensalism :** One species is benefitted and the other is neither benefitted nor harmed.
- **Amensalism :** One species is harmed and the other is unaffected.

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UNIT-X : ECOLOGY AND ENVIRONMENT

CHAPTER-6
BIODIVERSITY AND CONSERVATION

Revision Notes

Biodiversity and its Patterns

- **Biodiversity :** It is the diversity (or heterogeneity) of biological organisation ranging from cellular macromolecules to biomes.
- **Edward Wilson :** Popularized the term 'biodiversity' to describe the combined diversity at all levels of biological organization.
- **Levels of Biodiversity**
  - Biodiversity has been divided into three hierarchical levels of biological organization.

1. **Genetic diversity**
   (a) Diversity shown by a single species at the genetic level. *e.g.*, *Rauwolfia vomitoria* in Himalaya shows genetic variation in the potency and concentration of the chemical, reserpine.
   (b) India has more than 50,000 different strains of rice and 1,000 varieties of mango.
2. **Species diversity**
   Diversity at the species level. *e.g.*, Western Ghats have greater amphibian species than the Eastern Ghats.
3. **Ecological diversity**
   Diversity at ecosystem level. *e.g.*, In India, deserts, rain forests, mangroves, coral reefs, wetlands, estuaries & alpine meadows, all can be seen, whereas the Scandinavian countries (like, Norway, Sweden) have less ecological diversity.

- **Number of Species on Earth (Global Species Diversity)**
  - According to IUCN or International Union for Conservation of Nature & Natural Resources (2004) more than 1.5 million species have been described so far.
  - According to Robert May, the global estimate is about 7 million (considering the species are to be discovered in the tropics. *i.e.*, only 22% of the total species have been recorded so far).
  - Animals are more diverse (above 70%) than Plants including plantae and fungi (22%).
  - Most species-rich taxonomic group among animals are : Insects (70%, *i.e.*, out of every 10 animals, 7 are insects).
  - Number of fungal species is more than the combined total of the species of fishes, amphibians, reptiles and 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.
  - India has only 2.4% of the 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.
- Applying May's global estimate, India would have more than 1 lakh plant species and 3 lakh animal species.

➢ Patterns of Biodiversity

- Biodiversity is not uniform throughout the world. It varies with the change in latitude and altitude, it is affected by latitudinal gradients and species-area relationship. Following are the main 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.
  - **(i)** Colombia (near equator) has about 1400 species of birds.
  - **(ii)** New York (41° N) : 105 species of birds
  - **(iii)** Greenland (71° N) : 56 species of birds
  - **(iv)** India (tropical latitudes) : > 1200 species
- Tropical forest region like Ecuador has up to 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 :
  - **(i)** 40,000 species of plants
  - **(ii)** 3,000 species of fishes
  - **(iii)** 1,300 species of birds
  - **(iv)** 427 species of mammals
  - **(v)** 427 species of amphibians
  - **(vi)** 378 species of reptiles
  - **(vii)** 1,25,000 species of invertebrates
- Biodiversity (species richness) is highest in tropics because
  - **(i)** Tropics had more evolutionary time.
  - **(ii)** Relatively constant environment (less seasonal).
  - **(iii)** They receive more solar energy which contributes to greater productivity.

➢ (b) Species - Area Relationship

- According to the study of **Alexander von Humboldt** (German naturalist & geographer) in South American jungles, within a region, species richness increases with an increase in explored area, but only up to a limit.
- Relation between species richness and area for a wide variety of taxa (like, angiospermic plants, birds, freshwater fishes) gives a rectangular hyperbola.
- On a logarithmic scale, the relationship is a straight line or linear, 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 the species-area relationship among the large areas like entire continents, the slope of the line is steeper (Z value : 0.6 to 1.2). *e.g.*, for frugivorous birds and mammals in the tropical forests of different continents, the slope is 1.15.

➢ Importance of Species Diversity to the Ecosystem

- For many decades, ecologists believed that communities with more species, generally, tend to be more stable than those with fewer species.
- A stable community should not show too much variation in productivity from year to year; it must be either resistant or resilient to occasional disturbances (natural or man-made), and it must also be resistant to invasions by alien species.
- **David Tilman** found that plots with more species showed less year-to-year variation in total biomass.
- He also showed that in his experiments, increased diversity contributed to higher productivity.
- A rich biodiversity is not only essential for ecosystem health but imperative for the survival of the human race on this planet.
- Stanford ecologist **Paul Ehrlich** explained the effect of loss of species through his 'rivet popper hypothesis'.

➢ Loss of Biodiversity

- IUCN Red List (2004) says that 784 species (338 vertebrates, 359 invertebrates and 87 plants) became extinct in the last 500 years. *e.g.*, Dodo (Mauritius), Quagga (Africa), Thylacine (Australia), Stellar's sea cow (Russia) and 3 subspecies (Bali, Javan, Caspian) of the tiger.
- 27 species have disappeared in the last 20 years.
- The extinctions across taxa are not random. Some groups (like amphibians) appear to be more vulnerable to extinction.
- More than 15,500 species are facing the threat of extinction.
- 12% birds, 23% mammals, 32% amphibians, 31% gymnosperm species face the threat of extinction.

- On earth, there have been five mass extinctions of species and at present 'Sixth Extinction' is in progress.
- The current extinction rate is 100 - 1000 times faster than in 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 some environmental perturbations such as drought.
(c) Increased variability in ecosystem processes such as plant productivity, water use and pest and disease cycles.

➢ Causes of Biodiversity Losses ('The Evil Quartet')

- "The Evil Quartet" is the phrase coined by **Jared Diamond** to describe the four human induced causes of extinction.

➢ (a) Habitat Loss and Fragmentation

- It is the most important cause. *e.g.,* Tropical rain forests (loss from 14% to 6%).
- Thousands of hectares of rain forests are being lost within hours.
- The Amazon rain forest ('lungs of the planet') is being cut for cultivating soya beans or for the conversion of grasslands for cattle.
- When large habitats are broken up into small fragments due to various human activities, mammals and birds requiring large territories and certain animals with migratory habits are badly affected, leading to population decline.

➢ (b) Over-exploitation

- The dependence of humans on nature for food and shelter led to the over-exploitation of natural resources.
- **Example :** Many species like Stellar's sea cow, Passenger pigeon, etc. became extinct due to over-exploitation.
- Many marine fish populations around the world are over-harvested, endangering the continued existence of some commercially important species.

➢ (c) Alien Species Invasions

- When alien species are introduced unintentionally or deliberately, some of them turn invasive, and cause the decline or extinction of indigenous species.
- These alien species cause decline or extinction of indigenous species.
- **Example : (a)** The Nile Perch introduced in Lake Victoria (East Africa) caused extinction of more than 200 species of cichlid fish.
  (b) Invasive weed species like carrot grass (*Parthenium*), *Lantana* and water hyacinth (*Eichhornia*) caused damage to our native species.
  (c) The illegal introduction of the African Catfish (*Clarias gariepinus*) for aquaculture is posing a threat to the indigenous catfishes (*Clarias batrachus*) in our rivers.

➢ (d) Co-extinction

- When a species becomes extinct, the plant and animal species associated with it also become extinct.
- **Example : (a)** Extinction of the parasites takes place when the host is extinct.
  (b) In co-evolved plant-pollinator mutualism extinction of one leads to the extinction of the other.

Mnemonics

1.

Biodiversity and its Conservation

Concpet : Levels of Biodiversity
Mnemonic : Grand School Exhibition
Interpretation : Genetic diversity, Species diversity, Ecological diversity

Conservation of Biodiversity

Conservation Processes

➢ There are three main reasons for conserving the biodiversity which are categorized as follows :

(a) Narrowly Utilitarian Arguments

- Humans derive economic benefits from nature such as food, firewood, fibre, construction material, industrial products (tannins, lubricants, dyes, resins, perfumes) and medicines.

- 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 for i.e., 'bioprospecting' 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, bumblebees, birds and bats.
- Aesthetic pleasures such as walking through thick woods, watching spring flowers in full bloom or waking by hearing a bulbul's song in the morning.
- Other indirect benefits are pest control, climate moderation and flood control.

(c) Ethical Arguments

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

➢ CONSERVATION OF BIODIVERSITY

Types of Conservation

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

- It is the conservation of genetic resources within natural or human-made ecosystems in which they occur.
- E.g., Protected areas such as National Parks, Sanctuaries, Biosphere reserves, cultural landscapes, national 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.
- Collection of timbers, minor forest products and private ownership are allowed so long as they do not harm the animals.
- There are 553 wildlife sanctuaries in India.

(iii) Biosphere Reserves

- Areas of land or coastal environments to conserve the ecosystem and genetic resources contained therein.
- There are 18 biosphere reserves in India.

(iv) Sacred Forests (Sacred Groves)

- Sacred groves are highly protected forests because of religious and cultural traditions.
- Sacred groves in Khasi and Jaintia Hills in Meghalaya.
- Aravalli Hills of Rajasthan.
- Western Ghat regions of Karnataka & Maharashtra.
- Sarguja, Chanda and 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 earth.
- There are 36 hotspots in the world.
- 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%.
- 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 of from their natural habitat and placed in a 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 periods 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 periods 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.

Mnemonics

1.

Biodiversity and its Conservation

Concept : Conservation Biodiversity (*In-situ conservation*)
Mnemonic : National Service Best Service Hai
Interpretation : National park, Sanctuary, Biosphere reserve , Sacred forest, Hotspots

Know the Terms

- **Exotic species :** They are known as alien species that are introduced into a habitat by humans.
- **Biosphere reserve :** A reserve area for multiple uses of land but having many zones.
- **Red list :** A catalogue highlighting the challenged taxons that are on the verge of global extinction.
- **WCU :** World Conservation Union (formerly called IUCN).
- **IUCN :** International Union for Conservation of Nature and Natural resource.
- **Biodiversity :** It is the variety of living forms present in various ecosystems.
- **Genetic diversity :** Diversity shown by a single species at the genetic level.
- **Species diversity :** Diversity at the species level.
- **Ecological diversity :** Diversity at the ecosystem level.
- **Hotspots** : These are the areas or regions of high endemism and very high levels of species richness.
- **Extinct species :** Species that no longer exist on earth.
- ***In situ* conservation (on site) :** It is the conservation of genetic resources within natural or human-made ecosystems in which they occur.
- ***Ex situ* conservation (off site) :** It is the conservation of organisms outside their habitats.

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