UNIT – VIII : BIOLOGY IN HUMAN WELFARE

CHAPTER – 8 : HUMAN HEALTH AND DISEASE

Health:- It can be defined as a state of complete physical, mental and social well-being. When people are healthy, they are more efficient at work.

Health is affected by –

- Genetic disorders – heritable defects of parents to offspring.
- Infections and
- Life style including food and water we take, rest and exercise we give to our bodies, habits that we have or lack etc.

Diseases can be broadly grouped into infectious and non-infectious. Diseases which are easily transmitted from one person to another are called infectious diseases. Among non-infectious diseases, cancer is the major cause of death.

Common Diseases in Humans:

Pathogen :- Disease causing organisms.

Typhoid:

- Pathogen: *Salmonella typhi*.
- Symptoms: High fever, weakness, stomach pain, constipation, headache and loss of appetite, intestinal perforation and death may occur in severe cases. Typhoid fever could be confirmed by Widal test.
- Mode of transmission: These pathogens generally enter the small intestine through contaminated food and water and migrate to other organs through blood.

Pneumonia:

- Pathogen: *Streptococcus pneumoniae* and *Haemophilus infuenzae*.
- Symptoms: the alveoli get filled with fluid leading to severe problems in respiration. Symptoms include fever, chills, cough and headache, in severe cases the lips and finger nails may turn gray to bluish in colour.
- Mode of transmission: transmitted through droplets of infected persons.

Common Cold:

- Pathogen: Rhino viruses.
- Symptoms: nasal congestion and discharge, sore throat, hoarseness, cough, headache, tiredness.
- Mode of transmission: through droplets of infected persons.

DISEASES CAUSED BY PROTOZOANS.

Malaria.(means bad air)

- *Pathogen.* Protozoan *Plasmodium* vivax.
- Vector. Female Anopheles mosquito
- *Symptoms.* Head aches, muscle pain, high fever. During fever the patient feels chill and shivering.
- *Prevention.* Eradication of vector and keeping the surrounding clean.
- *Treatment.* It involves the use of medicine like quinine and protection of patients from the mosquitoes.
- *Mode of spread.* This disease spreads by the bite of infected Anopheles mosquito. Only the female Anopheles is capable of spreading the disease because it sucks the blood of man.

Amoebiasis.

- *Pathogen.* It is due to an intestinal protozoan parasite *Entamoeba histolytica*.
- *Symptoms.* This parasite lives in the large intestine and destroys the mucus membrane. This may cause bleeding and ulcer that produce dysentery. Hence patient passes out blood and mucus with the stool. There will be severe pain in abdomen, fever, nausea and nerveness.
- *Mode of transmission.* As the cysts of pathogen are found in the intestinal discharge he possibility of infection to healthy persons is through contaminated water or improperly washed or cooked vegetables and fruits. The pathogen can also be transmitted through dirty hands.
- *Prevention.* Proper disposal of faecal matter of the patient. Vegetables and fruits when used raw, should be thoroughly washed. Water should be boiled before drinking.

DISEASE CAUSED BY HELMINTHES WORM.

Ascariasis.

- Pathogen. A round worm *Ascaris lumbricoides*.
- Symptoms. This parasite is found in the small intestine of man and is of world wide distribution. It causes a lot of stomach ache, nausea and cough.
- M.T. Through food, when soil consist of cyst and eggs, it will be transmitted through vegetables growing on it or through dirty hands or by ingestion of soil.
- Prevention.
- The disposal of human faeces by underground sewer canals is an efficient measure to prevent the spread.
- Washing of vegetables and fruits before eating help of keep away the eggs of the worm.

Filariasis.

- Pathogen. *Wuchereria bancrofti*.
- Vector. Culex mosquito.

- Symptoms. The worm lives in the lymph vessels and block them, this causes swelling of the body parts like, legs scrotum, foot, etc. This enlargement of legs gives the disease its name as Elephantiasis.
- Prevention. Eradication of vector.

DISEASE CAUSED BY FUNGI

Ringworms:

- Pathogens: *Trichophyton* and *Epidermophyton*
- Symptoms: appearance of dry, scaly lesions on various parts of the body such as skin, nails and scalp with intense itching.

Measures for prevention and control of infectious diseases –

- **Personal hygiene:** It includes cleanliness of body, drinking of clean water, etc.
- **Public hygiene:** It includes cleaning of water reservoirs, proper disposal of sewage, etc.

Immunity

Ability of the body to fight infectious agents
On the basis of the immunity possessed by the body, immunity can be innate immunity and acquired immunity.

1. **Innate immunity:** a non-specific type of defense mechanism. It has four types of barriers –

- Physical barrier: Example, skin covering of the body, secretion of mucous in the respiratory tract
- Physiological barrier: Example, acid in the stomach, tears from the eyes
- Cellular barrier: Example, monocytes and lymphocytes in blood
- Cytokine barrier: Example, interferon

2. **Acquired immunity**: It is a specific type of defense mechanism. It shows two types of responses: primary response and secondary response. It involves two types of lymphocytes –

- B lymphocytes: Show humoral immune response (HI)
- T lymphocytes: Show cell mediated immunity (CMI)

Structure of an Antibody:

The antibodies are protein molecules called immunoglobulins and are of various types like IgA, IgM, IgE, IgG.
Each antibody molecule consists of four polypeptide chains, two are long called heavy chains and other two are short called light chains. Both are arranged in the shape of 'Y', hence an antibody is represented as H2L2.

On the basis of production of antibodies, immunity can be further categorized as –

- Active immunity: Body produces its own antibodies against antigens
- Passive immunity: Readymade antibody is transferred from one individual to another
  Colostrum (contains antibodies IgA) is an example of passive immunity provided by the mother to her child.

Auto immunity:
Production of antibodies against the tissues of its own cells. Example – Rheumatoid arthritis.

Lymphoid organs:
It acts as the sites of formation and maturation of lymphocytes.

Primary lymphoid organ – where lymphocytes are produced and matured. Example – Bone marrow and Thymus.

Secondary lymphoid organ– where lymphocytes fight with antigens. Example - Spleen, lymph nodes, tonsils, Peyer's patches Mucosal Associated Lymphocyte Tissues (MALT).

Vaccination:
It is the protection of the body from communicable diseases by administration of agents (called vaccines) that mimic the microbes. Vaccines are available against tetanus, polio, etc.

Allergies:
Hypersensitivity to a particular allergen (such as pollens, dust) is termed as allergy. IgE is an antibody responsible for allergy. Symptoms include, sneezing, watery eyes, running nose and difficulty in breathing. Allergy is due to secretion of histamine and serotonine by mast cells. Allergy is treated with anti-histamine, adrenaline and steroids.

AIDS (Acquired immunodeficiency syndrome):

It can spread –

- through sexual contact with the infected person
- from the mother to her child, through the placenta
- infected blood transfusion
- by the use of infected syringe
- It is caused by HIV virus (a retro virus) and has RNA as genetic material. HIV stands for Human Immunodeficiency Virus.

When HIV virus enters the host cell, the virus enters into macrophages, where RNA replicates and forms viral DNA by the help of enzyme reverse transcriptase. The viral

DNA gets incorporated into the host cell's DNA and directs the infected cells to produce daughter viruses. The macrophages continue to produce virus that enters the helper T-lymphocytes. Thus the number of helper T-lymphocytes progressively decreases in the body and weaken the immune system.

Diagnostic test for AIDS: ELISA (enzyme-linked-immuno-sorbent assay)

Cancer

Tumour caused by abnormal and uncontrolled cell division. It is of two types –
Benign tumour: Remains confined to a particular location and does not spread
Malignant tumour: Cells divides and invades new locations by getting transported through blood to distant sites
Metastasis: Property of malignant tumour to invade the distant body parts, thereby initiating formation of new tumours.

Carcinogen: Cancer-causing agents; e.g., X-rays, UV rays

Cancer detection and diagnosis: Techniques involved are radiography, computed tomography and magnetic resonance imaging

Treatment of cancer:

- Surgical – cancerous tissues are surgically removed.
- Radiotherapy – tumor cells are irradiated lethally by radiation.
- Chemotherapy – drugs are used to kill cancerous cells, but shows side effects like hair loss, anemia, etc.
- Immunotherapy – patients are given with alpha-interferon which activate their immune system and help in destroying the tumor.

Drugs and Alcohol

Drugs and alcohol abuse includes –

- Opioids: Morphine is obtained from Poppy plant. It is a sedative (depressant) and pain killer. Heroin is chemically diacetylmorphine. It slows down body functions. Example, Heroin (extracted from Papaver somniferum)
- Cannabinoids: Itis obtained from Cannabis sativa. These are taken by inhalation and oral ingestion, they affect the cardiovascular system of the body. Example, marijuana, hashish, charas, ganja (obtained from Cannabis sativa),
- Coca alkaloids / Cocaine: it is obtained from Erythroxylon coca. It is taken by smoking. It is a stimulant and activates central nervous system.
- Hallucinogens: It is obtained from Atropa belladonna and Datura sp. LSD (Lysergic acid Diethylamide) is obtained from fungus.

- Tobacco: it contains nicotine, which is stimulant. It stimulates adrenaline and increases the secretion of adrenaline. Smoking of tobacco leads to lung cancer, bronchitis, emphysema, coronary heart diseases.

Adolescence and Drug abuse

Adolescence is the period during which the child becomes matured.
It is between 12 – 18 years of age.

Causes of drug abuse –

- Curiosity
- Adventure
- Excitement
- Experimentation
- Stress or pressure to excel in examination

Effects of drug/alcohol abuse –

- Reckless behavior
- Malicious mischief
- Violence
- Drop in academic performance
- Depression, isolation, aggressiveness, etc.

Prevention and control –

- Avoid peer pressure
- Counseling and education
- Take help from teachers, parents and peers
- Take professional and medical help

CHAPTER – 9 : STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION

Animal Husbandry:

It is the agricultural practice of breeding and raising livestock. Animal husbandry deals with the care and breeding of livestock like buffaloes, cows, pigs, horses, cattle, sheep, camels goats, etc., that are useful to humans.

Management of Farms and Farm Animals:

1) Dairy Farm Management:

Dairying is the management of animals for milk and its products for human consumption. In dairy farm management, we deal with processes and systems that increase yield and improve quality of milk.

- Selection of good breeds having high yielding potential, combined with resistance to diseases is very important.
- Cattle have to be housed well, should have adequate water and be maintained disease free.
- The feeding of cattle should be carried out in a scientific manner (quality and quantity of fodder).
- Stringent cleanliness and hygiene are importance while milking, storage and transport of the milk and its products.

2) Poultry Farm Management:

- Poultry is the class of domesticated fowl used for food or for their eggs.
- Selection of disease free and suitable breeds, proper and safe farm conditions, proper feed and water, and hygiene and health care are important components of poultry farm management.

Animal Breeding:

- Animal breeding aims at increasing the yield of animals and improving the desirable qualities of the produce.
- When breeding is between animals of the same breed it is called Inbreeding, while crosses between different breeds are called Outbreeding.

Inbreeding:

- It refers to the mating of more closely related individuals within the same breed for 4-6 generations. The breeding strategy is, superior males and superior females of the same breed are identified and mated in pairs.
- Inbreeding increases Homozygosity. However, continued inbreeding, especially close inbreeding, usually reduces fertility and even productivity. This is called Inbreeding Depression. Whenever this becomes a problem, selected animals of the breeding population should be mated with unrelated superior animals of the same breed. This usually helps restore fertility and yield.

Out-breeding:

It is the breeding of the unrelated animals, which may be between individuals of the same breed or between different breeds or different species.

Out-crossing:

This is the practice of mating of animals within the same breed, but having no common ancestors on either side of their pedigree up to 4-6 generations. The offspring of such a mating is known as an out-cross. A single outcross often helps to overcome inbreeding depression.

Cross-breeding:

In this method, superior males of one breed are mated with superior females of another breed. Cross-breeding allows the desirable qualities of two different breeds to be combined. The progeny hybrid animals may themselves be used for commercial production. For example, Hisardale is a new breed of sheep developed in Punjab by crossing Bikaneri ewes and Marino rams.

Interspecific Hybridisation:

In this method, male and female animals of two different species are mated. In some cases, the progeny may combine desirable features of both the parents, and may be of considerable economic value. Eg. Mule.

Artificial Insemination:

Controlled breeding experiments are carried out using artificial insemination. The semen is collected from the male that is chosen as a parent and injected into the reproductive tract of the selected female by the breeder.

The success rate of crossing mature male and female animals is fairly low even though artificial insemination is carried out.

To improve chances of successful production of hybrids, other means are also used (MOET).

Multiple Ovulation Embryo Transfer Technology (MOET):

In this method, a cow is administered hormones, with FSH-like activity, to induce follicular maturation and super ovulation-instead of one egg, which they normally yield per cycle; they produce 6-8 eggs. The animal is either mated with an elite bull or artificially inseminated. The fertilized eggs at 8-32 cells stages, are recovered non-surgically and transferred to surrogate mothers. The genetic mother is available for another round of super ovulation.

3) Bee-keeping / Apiculture:

Bee-keeping or Apiculture is the maintenance of hives of honeybees for the production of honey. There are several species of honeybees which can be reared. Of these, the most common species is *Apis indica*.

Honey is a food of high nutritive value and also finds use in the indigenous systems of medicine. Honeybee also produces beeswax, which finds many uses in industry, such as in the preparation of cosmetics and polishes of various kinds.

The following points are important for successful bee-keeping:

- Knowledge of the nature and habits of bees,
- Selection of suitable location for keeping the beehives,
- Catching and hiving of swarms (group of bees),
- Management of beehives during different seasons, and
- Handling and collection of honey and of beeswax.
- Keeping beehives in crop fields during flowering period increases pollination efficiency and improves the yield.

4) Fisheries:

- Fishery is an industry devoted to the catching, processing or selling of fish, shellfish or other aquatic animals. Freshwater fishes – Catla, Rohu and common crab; Marine fishes – Hilsa, Sardines, mackerel and Pomfrets.
- In order to meet the increasing demands on fisheries, different techniques have been employed to increase production.
- Through aquaculture and pisciculture we have been able to increase the production of aquatic plants and animals, both fresh-water and marine.

II Plant Breeding:

Green revolution was dependent to a large extent on plant breeding techniques for development of high – yielding and disease resistant varieties in wheat, rice, maize, etc.

What is Plant Breeding?

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

The main steps in breeding a new genetic variety of a crop are –

a) *Collection of variability* – Collection and preservation of all the different wild varieties, species and relatives of the cultivated species.
b) *Evaluation and selection of parents* – Evaluation is done to identify plants with desirable characters. The selected plants are multiplied and used in the process of hybridization.
c) *Cross hybridization among the selected parents* – By cross hybridizing the two parents to produce hybrids that genetically combine the desired characters in one plant.
d) *Selection and testing of superior recombinants* – The selection process is crucial to the success of the breeding objective and requires careful scientific evaluation of the progeny. These are self pollinated for several generations till they reach a state of uniformity, so that the characters will not segregate in the progeny.
e) *Testing, release and commercialization of new cultivars* – This evaluation is done by growing these plants in the research fields and recording their performance under ideal fertilizer application irrigation, and other crop management practices. It will be followed by testing the materials in farmers' fields, for at least three growing at several locations in the country.

Wheat and Rice:

- In 1963, several varieties such as *Sonalika* and *Kalyan Sona*, which were high yielding and disease resistant, were introduced all over the wheat-growing belt of India.
- Semi-dwarf rice varieties wre derived from *IR-8*, and *Taichung Native-1* were introduced in 1966. Later better-yielding semi-dwarf varieties *Jaya* and *Ratna* were developed in India.

Sugar cane:

- *Saccharum barberi* and *Saccharum officinarum* were crossed to get the desirable qualities of high yield, thick stems, high sugar and ability to grow in the sugar cane areas of north India.

Millets:

- Hyrbid maize, jowar and bajra have been developed in India, which are high yielding and resistant to water stress.

a) Plant Breeding for Disease Resistance:

Methods of Breeding for disease resistance:

The various sequential steps are;

Screening germplasm for resistance, hybridization of selected parents, selection and evaluation of the hybrids and testing and release of new varieties.

CROP	VARIETY	RESISTANCE TO DISEASES
Wheat	Himgiri	Leaf and stripe rust, hill bunt
Brassica	Pusa swarnim	White rust
Cauliflower	Pusa Shubhra, Pusa Snowball K – 1	Black rot and Curl blight black rot
Cowpea	Pusa Komal	Bacterial blight
Chilli	Pusa Sadabahar	Chilly mosaic virus, Tobacco mosaic virus and Leaf curl

Mutation Breeding:

- It is the process by which genetic variations are created through changes in the base sequence within genes resulting in the creation of a new character or trait not found in the parental type.
- It is possible to induce mutations artificially through use of chemicals or radiations, and selecting and using the plants that have the desirable character as a source in breeding.
- For example, in mung bean, resistance to yellow mosaic virus and powdery mildew were induced by mutations.
- Resistance to yellow mosaic virus in bhindi (*Abelmoschus esculentus*) was transferred from a wild species and resulted in a new variety of *A. esculentus* called *Parbhani kranti*.

b) Plant Breeding for Developing Resistance to Insect Pests:

- Insect resistance in host crop plants may be due to morphological, biochemical or physiological characteristics.
- Hairy leaves in several plants are associated with resistance to insect pests, e.g., resistance to jassids in cotton and cereal leaf beetle in wheat.

- High aspartic acid, low nitrogen and sugar content in maize leads to resistance to maize stem borers.
- Smooth leaved and nectar-less cotton varieties do not attract bollworms.

CROP	VARIETY	INSECT PESTS
Brassica	Pusa Gaurav	Aphids
Flat bean	Pusa Sem 2, Pusa Sem 3	Jassids, aphids and fruit borer
Okra (bhindi)	Pusa Sawani, Pusa A – 4	Shoot and Fruit borer

c) Plant Breeding for Improved Food Quality:

- Diets lacking essential micronutrients – particularly iron, vitamin A, iodine and zinc – increase the risk for disease, reduce lifespan and reduce mental abilities.

Biofortification:-

It is the process of breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats.

Breeding for improved nutritional quality is undertaken with the objectives of improving;

- Protein content and quality
- Oil content and quality
- Vitamin content ; and
- Micronutrient and mineral content
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Examples;- Vitamin A enriched carrots, spinach, pumpkin; Vitamin C enriched bitter gourd, mustard, tomato; Iron and Calcium enriched spinach and Protein enriched Beans.

d) Single Cell Protein (SCP):

- Single cell proteins can be produced from algae, fungi, yeasts and bacteria.
- Some low-cost substrates are used to produce microbial biomass to produce single cell proteins.
- SCP is rich in high quality protein and is low in fat content, hence it is a desirable human food.
- SCP should also reduce the pressure on agricultural production systems for the supply of proteins and it can reduce environmental pollution.
- For example, microbes like Spirulina can be grown easily on materials like waste water from potato processing plants, straw, molasses, animal manure and even sewage, to

produce large quantities and can serve as food rich in protein, minerals, fats, carbohydrate and vitamins.

d) Tissue Culture:

Plant tissue culture refers to the maintenance and growth of plant cells, tissues and organs on a suitable synthetic medium in vitro and the whole plants could be regenerated from explants.

Explant:

An explant is the plant part excised from a specific location in a plant, to be used for initiating a culture.

In this tissue culture process, explant, i.e., any part of a plant is taken out and grown in a test tube, under sterile conditions in special nutrient media. This capacity to generate a whole plant from any cell / explant is called Totipotency. This method of producing thousands of plants through tissue culture is called Micropropagation. Each of these plants will be genetically identical to the original plant from which they were grown i.e., they are somaclones.

Somatic Hybridisation / Somatic Hybrids:

The first step in somatic hybridization is to remove the cell wall by digesting it with enzymes like pectinase and cellulase.

Isolated protoplasts from two different varieties of plants – each having a desirable character – can be fused to get hybrid protoplasts, which can be further grown to form a new plant. These hybrids are called somatic hybrids while the process is called somatic hybridization. For example, a protoplast of tomato is fused with that of potato to form new hybrid plants combining tomato and potato characteristics.

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CHAPTER – 10 : MICROBES IN HUMAN WELFARE

Microbes in Household products:

- A common example is the production of curd from milk. Micro-organisms such as Lactobacillus and others commonly called Lactic Acid Bacteria (LAB) grow in milk and convert it to curd. During growth, the LAB produce acids that coagulate and partially digest the milk proteins. It also improves its nutritional quality by increasing vitamin B_{12}. In our stomach too, the LAB play very beneficial role in checking disease causing microbes.
- The dough, which is used for making bread, is fermented by using baker's yeast (*Saccharomyces cerevisiae*).
- "Toddy", a traditional drink of some parts of southern India is made by fermenting sap from palms.
- Microbes are also used to ferment fish, soyabean and bamboo-shoots to make foods. Cheese, is one of the oldest food items in which microbes were used. The large holes in 'Swiss cheese' are due to production of a large amout of CO_2 by a bacterium named *Propionibacterium sharmanii*. The 'Roquefort cheese' is ripened by growing a specific fungus on them for a particular flavour.

Microbes in Industrial products:

Production on an industrial scale requires growing microbes in very large vessels called Fermentors.

a) Fermented Beverages:

The yeast *Saccharomyces cerevisiae* used for bread making and commonly called brewer's yeast, is used for fermenting malted cereals and fruit juices to produce ethanol. Wine and beer are produced without distillation whereas whisky, brandy and rum are produced by distillation of the fermented broth.

b) Antibiotics:

Antibiotics are chemical substances, which are produced by some microbes and can kill or retard the growth of other disease causing microbes.

Pencillin was the first antibiotic to be discovered and it was a chance discovery. Alexander Fleming while working on Staphylococci bacteria, once observed a mould growing in one of his unwashed culture plates around which *Staphylococci* could not grow. He found out that it was due to a chemical produced by the mould and he named it Pencillin after the mould *Pencillium notatum*. Later, Ernest Chain and Howard Florey made its full potential effective antibiotic.

c) Chemicals, Enzymes and other Bioactive Molecules:

- *Aspergillus niger* (fungus) – Citric acid
- *Acetobacter aceti* (bacterium) – Acetic acid
- *Clostridium butylicum* (bacterium) – Butyric acid
- *Lactobacillus* (bacterium) – Lactic acid
- *Saccharomyces cerevisiae* – Ethanol

Enzymes:

- Lipase – used in laundry detergents
- Pectinase and protease – used in bottled juices
- Streptokinase (*Streptococcus bacterium*) – used as clot buster (to remove clots)

Bioactive molecules:

- Cyclosporin A (*Trichoderma polysporum* fungi) – used as immunosuppressive agent (for organ transplant patients).
- Statins (*Monascus purpureus* yeast) – used as blood cholesterol lowering agents.

Microbes in Sewage Treatment:

Treatment of waste waster is done by heterotrophic microbes naturally present in the sewage. This treatment is carried out in two stages;

Primary treatment / Physical treatment:

It involves physical removal of particles from the sewage through filtration and sedimentation.

- Sequential filtration – to remove floating debris
- Sedimentation – to remove grit (soil and small pebbles)

All solids that settle form the primary sludge, and the supernatant forms the effluent. The effluent from the primary settling tank is taken for secondary treatment.

Secondary treatment / Biological treatment:

- The primary effluent is passed into large aeration tanks, this allows vigorous growth of aerobic microbes into flocs. While growing, these microbes consume the major part of the organic matter in the effluent. This significantly reduces the BOD (biochemical oxygen demand) of the effluent. BOD is a measure of the organic matter present in the water. The greater the BOD of waste water, more is its polluting potential.
- Once the BOD of sewage water is reduced significantly, 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 this 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.
- During this digestion, bacteria produce a mixture of gases such as methane, hydrogen sulphide and carbon dioxide. These gases form biogas.
- The effluent from the secondary treatment plant is generally released into natural water bodies like rivers and streams.

Microbes in Production of Biogas:

Biogas is mixture of gases produced by the microbial activity and which may be used as fuel. Certain bacteria, which grow anaerobically on cellulosic material, produce large amount of methane along with CO_2 and H_2. These bacteria are collectively called Methanogens (*Methanobacterium*).

These bacteria are also present in the rumen of cattle. A lot of cellulosic material present in the food of cattle is also present in the rumen. In rumen, these bacteria help in the breakdown of cellulose and play an important role in the nutrition of cattle. Thus, the excreta (dung) of cattle, commonly called Gobar, is rich in these bacteria. Dung can be used for generation of biogas commonly called gobar gas.

Biogas Plant:

- The technology of biogas production was developed in India mainly due to the efforts of Indian Agricultural Research Institute (IARI) and Khadi and Village Industries Commission (KVIC).
- The biogas plant consists of a concrete tank in which bio-wastes are collected and slurry of dung is fed.
- A floating cover is placed over the slurry, which keeps on rising as the gas is produced in the tank due to the microbial activity.
- The biogas plant has an outlet, which is connected to a pipe to supply biogas to nearby houses.
- The spent slurry is removed through another outlet and may be used as fertilizer.
- The biogas thus produced is used for cooking and lighting.

Microbes as Biocontrol Agents:

Biological control of pests and diseases:

- Lady bird – to control aphids
- Dragon fly – to control mosquitoes
- *Bacillus thuringiensis* ***(Bt Cotton)*** – to control wide range insects
- *Trichoderma* (fungi) – protects root system and control plant pathogens.
- Baculoviruses (*Nucleopolyhedrovirus*) – to attack insects and other arthropods.

Microbes as Biofertilisers:

Biofertilizers are organisms that enrich the nutrient quality of the soil. The main sources of biofertilisers are bacteria, fungi and cyanobacteria.

Bacteria:

- Symbiosis – *Rhizobium* with root nodules of leguminous plants
- Free living (in the soil) – *Azotobacter* and *Azospirillum*.

Fungi:

- Symbiosis – Mycorrhiza with root system of genus *Glomus* and absorb phosphorus and water from the soil for the plant growth.

Cyanobacteria:

- Symbiosis – *Anabaena* in *Azolla*
- Free living – *Nostoc, Oscillatoria* and Blue green algae.

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