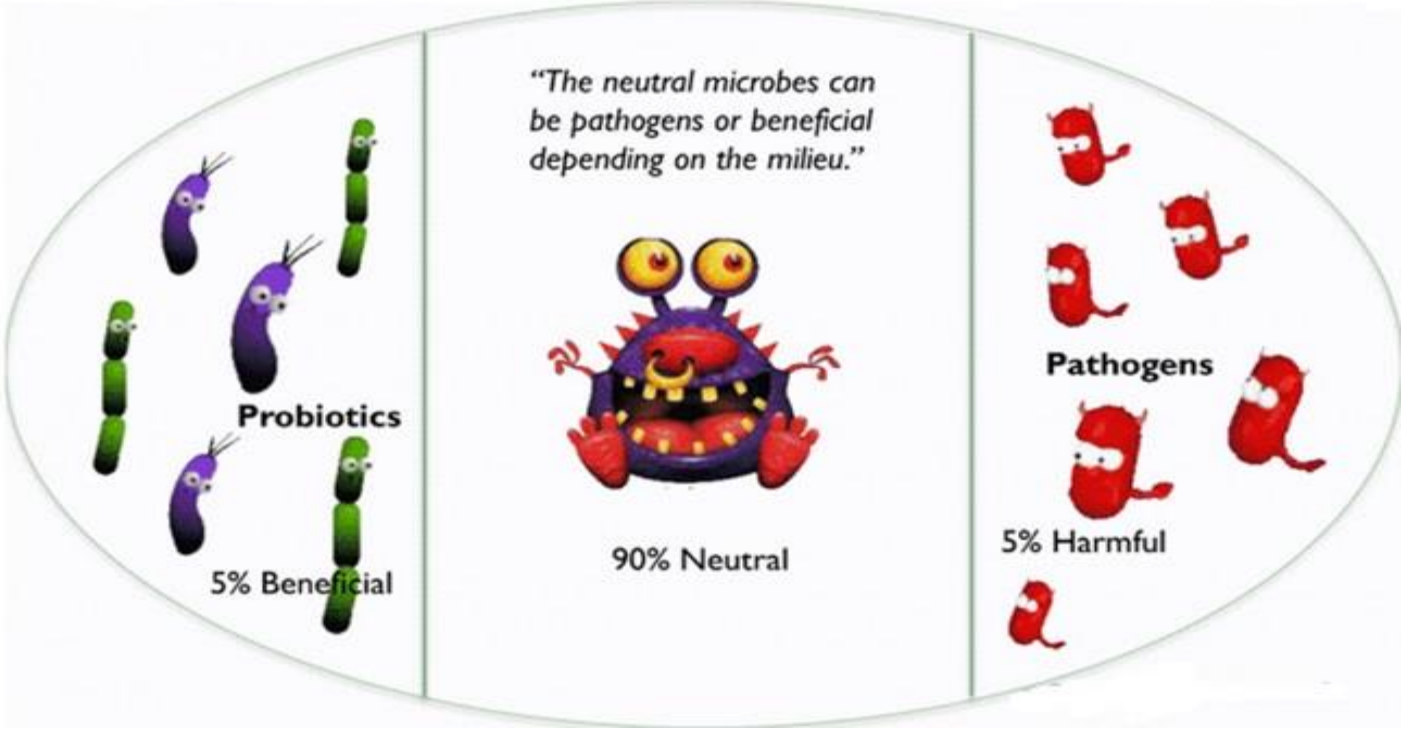
BIOLOGY AND DIVERSITY OF VIRUSES, BACTERIA AND FUNGI (PAPER CODE: BOT 501)



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OBJECTIVES

The main objective of the present lecture is to cover the topic and make it easy to understand and interesting for our students/learners.

BLOCK – II : BACTERIA

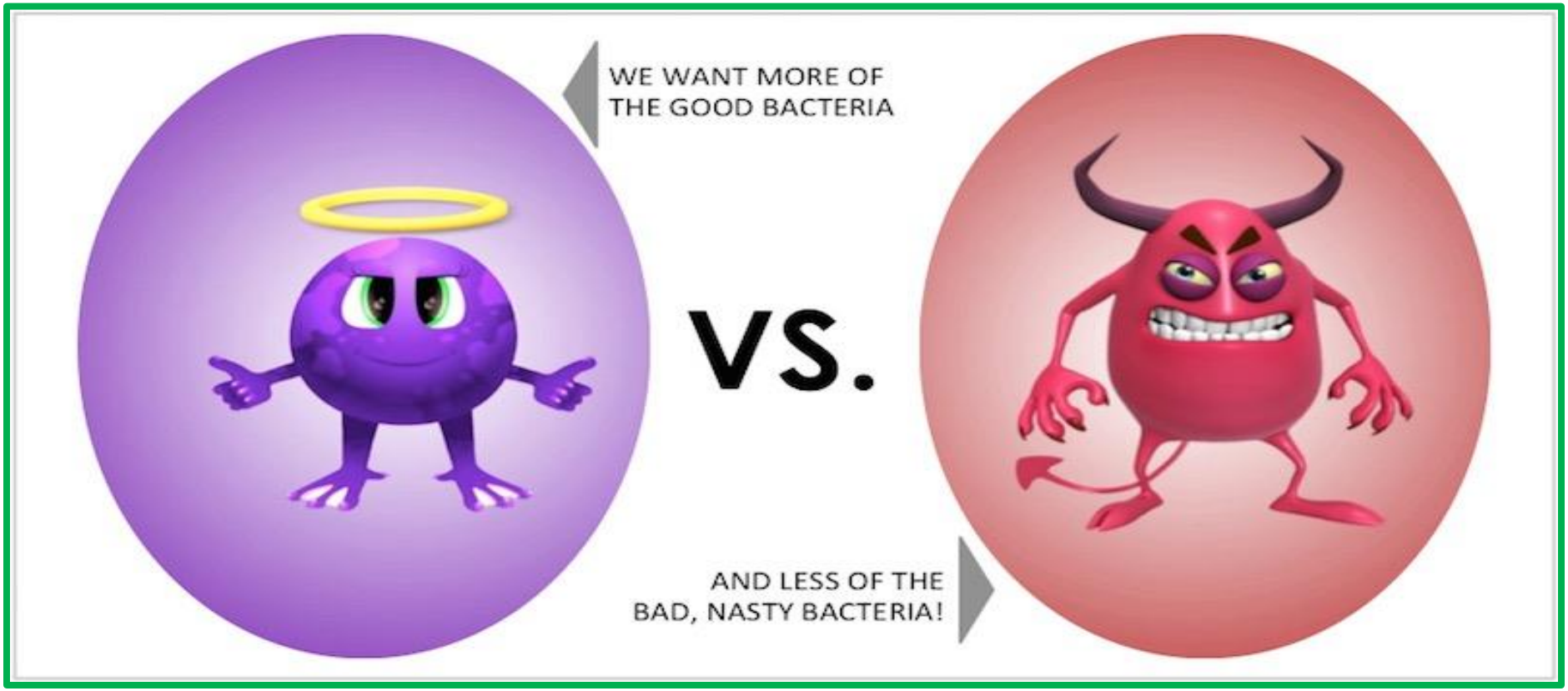
Unit – 8 : Economic Importance of Bacteria

CONTENT

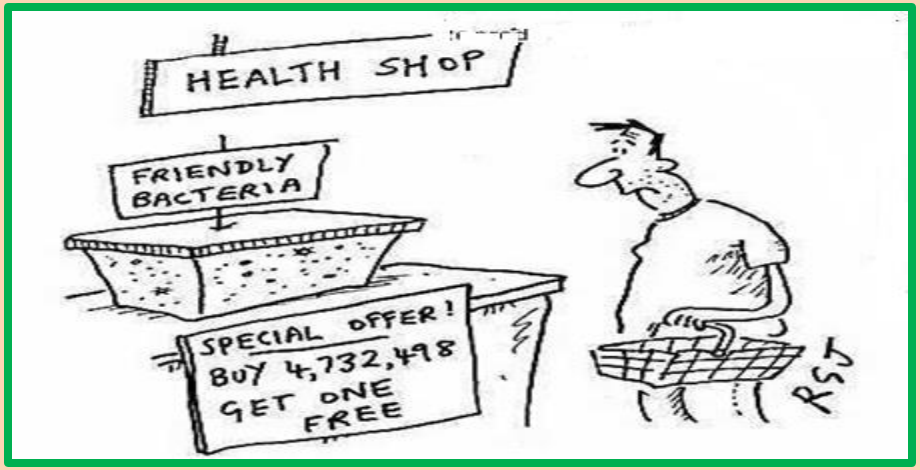
- Economic importance of bacteria
  - Beneficial effects
    - ✓ Role in agriculture
    - ✓ Role in industries
    - ✓ Role in waste water treatment
    - ✓ Role in biological control of insects
  - Harmful effects
    - ✓ Role in food spoilage
    - ✓ Role in water pollution
    - ✓ Role in reduction of soil fertility
    - ✓ Role in diseases
- Key points of the lecture
- Terminology
- Assessment Questions
- Bibliography

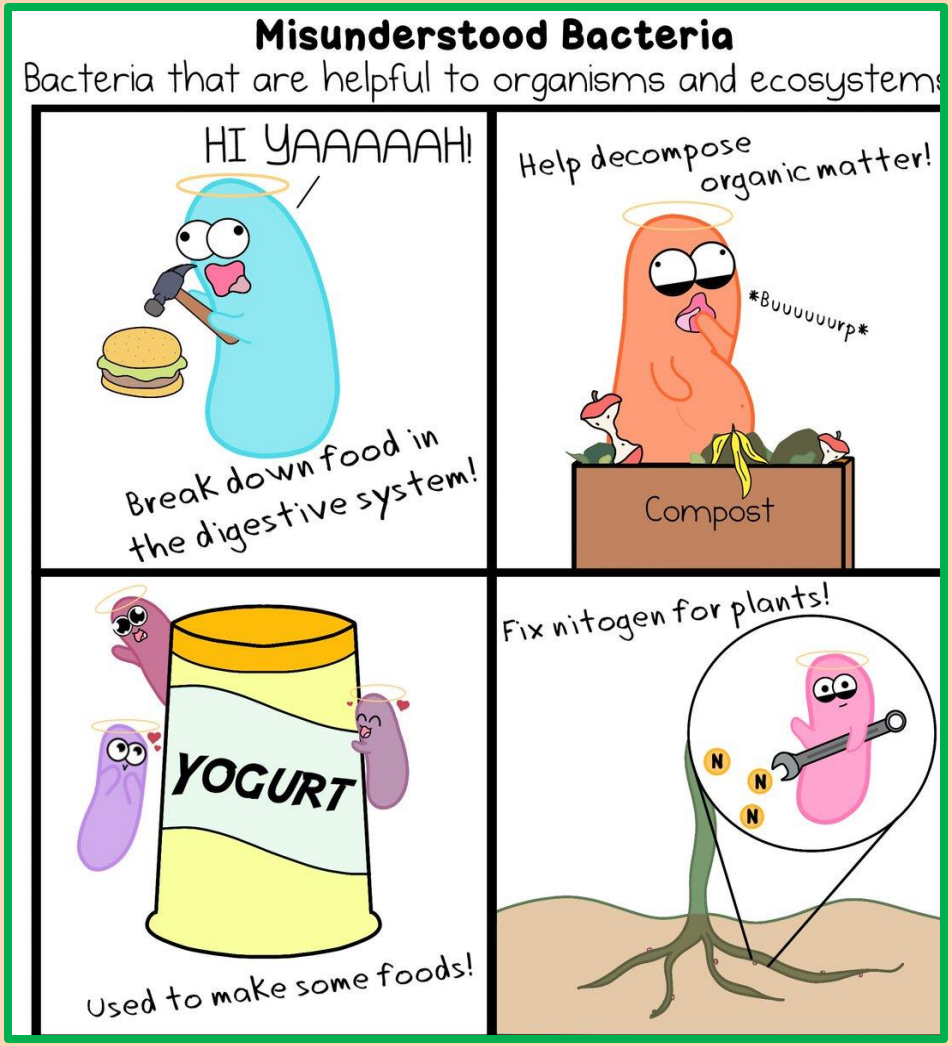
ECONOMIC IMPORTANCE OF BACTERIA

- The bacteria are best known to the general public as the causative agent of diseases. We must not forget that the bacteria do not always means diseases. Many of them are positively beneficial. Several others are neither harmful nor beneficial. Only a very small are harmful. The bacteria performs the two type of activities;
  - Beneficial Activities
  - Harmful Activities



BENEFICIAL ACTIVITIES OF BACTERIA





There are many kinds of bacteria without which we could not live. They are absolutely essential to the presence of life on earth. They make possible the continued existence of green plants and therefore of animals because the plants are the only source of food for animals.

❑ Role in Agriculture

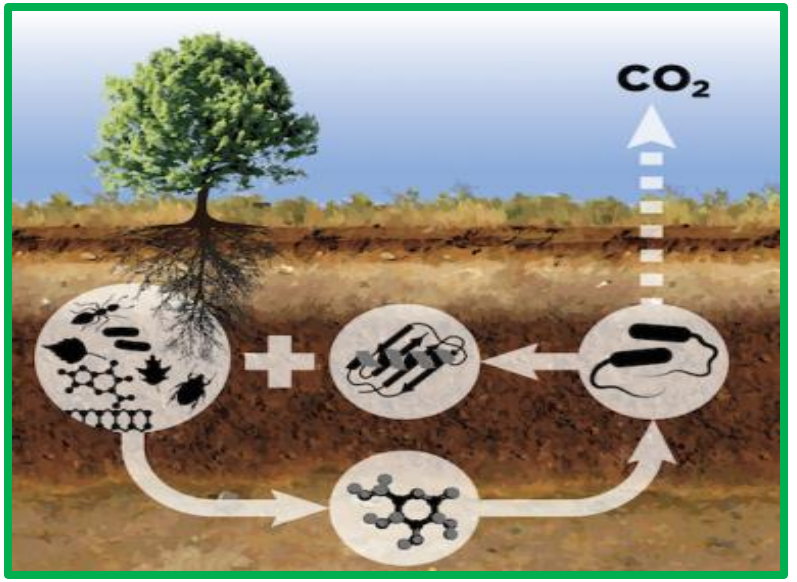
(i) **Decay and decomposition:** Soil bacteria play an important role in brining about decomposition of organic matter. They serve a double purpose. In the first instance they act as scavengers removing harmful waste from the earth.

❖ Secondly, they return it to the soil as plant food. The dead bodies and wastes of organisms (both plants and animals) are decomposed by the activities of the saprophytic bacteria.

❖ In consequence a variety of elements of minerals of the earth such as carbon, oxygen, hydrogen, sulphur and phosphorus which make up their bodies are reduced to simple compounds such as carbon monoxide, water, nitrates, sulphates and phosphates.

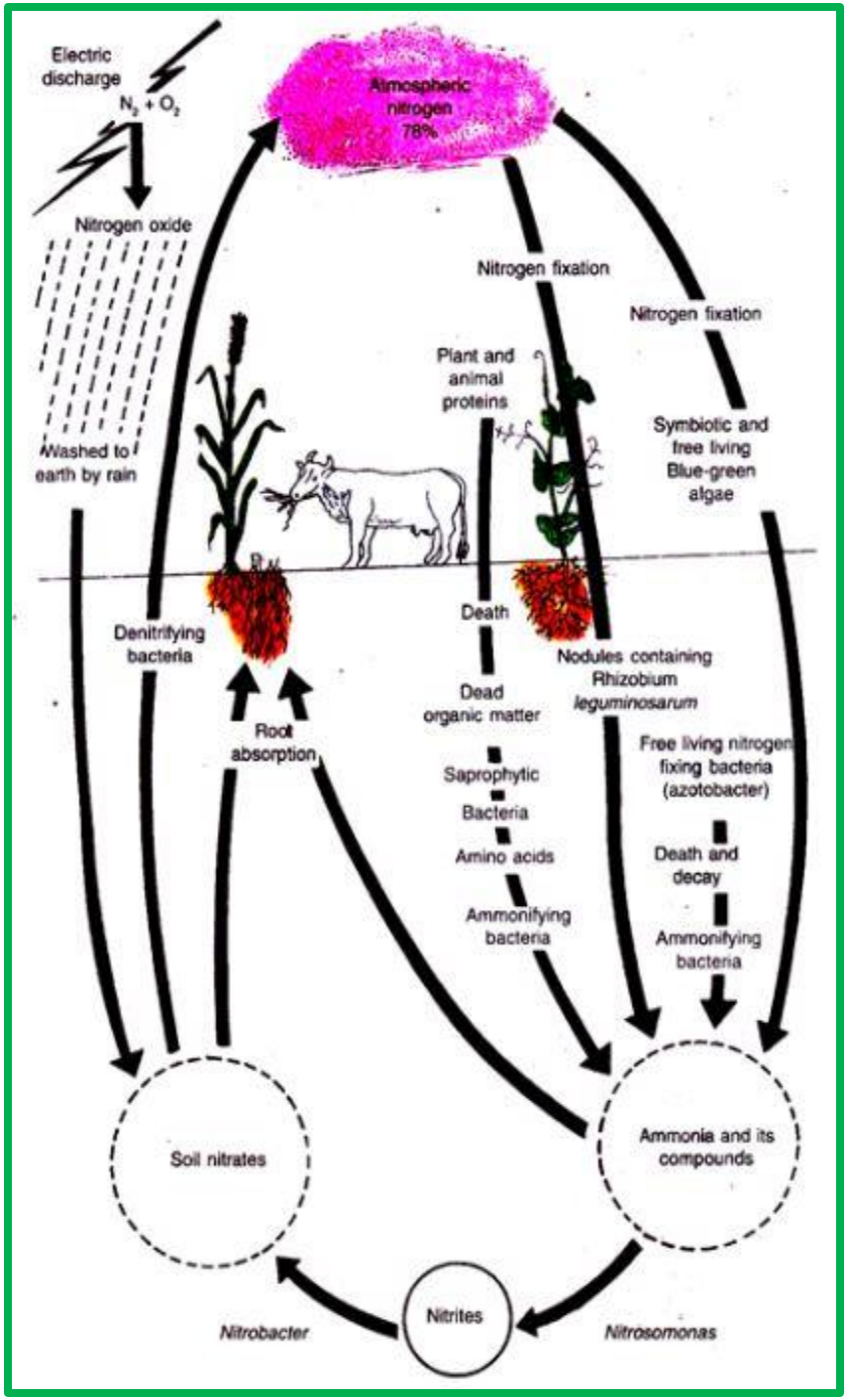
❖ Some of these go back to the soil and the rest to the air. From the soil they can be absorbed as plant food. This activity of the bacteria is used in sewage disposal system of cities. The bacterial action on the city's sewage promotes decay.

❖ Finally purified and changed into an odourless and valuable fertiliser instead waste product.



(ii) Soil fertility: Some bacteria play an important role in maintaining and others in increasing soil fertility. The fertility of soil is proportional to its nitrogen content.

- Atmosphere, no doubt, is four-fifths (8o%) nitrogen, green plants generally are unable to use it. They mostly absorb it as nitrates and to some extent as ammonia from the soil.
- Continuous absorption of these salts results in their exhaustion in the soil. Nearly all fertilisers for the soil include a large proportion of such soluble nitrogen compounds to promote plant.
- In nature the presence of a regular supply of these salts is ensured by bacteria of certain types. These bacteria which function as Nature's farmers belong to three categories, namely, ammonifying bacteria, nitrifying bacteria and nitrogen-fixing bacteria.
- They are the agents of maintaining a continual circulation of nitrogen in nature between the plant world, in soil and the atmosphere. The series of changes through which the nitrogen passes due to the activities of these organisms constitute the nitrogen cycle.



(a) **Ammonifying Bacteria:** The saprophytic bacteria break down the proteins and other nitrogen containing remains of the plant and animal origin in the soil to amino acids by secreting enzymes. The amino acids are then converted into ammonia by a group of bacteria called the ammonifying bacteria. The liberated ammonia may combine with carbon dioxide and water in the soil to form ammonium carbonate. A few plants such as the common cereals can make use of ammonium compounds as a source of nitrogen. The majority of plants, however, cannot absorb ammonium compounds as a source of nitrogen.

(b) **Nitrifying Bacteria:** Ammonia is very soluble. It moves in the soil rapidly and is acted upon by microorganisms of the category of chemosynthetic autotrophs in the soil. They are the nitrifying bacteria such as *Nitrosomonas* and *Nitrobacter*. They form nitrates from ammonium compounds. The reaction takes place in the following two steps:

Nitrosomonas $NH_4^+ + 2O_2 \longrightarrow 2H_2O + NO_2 \uparrow$ energy

Nitrobacter $NO_2^- + \frac{1}{2}O_2 \longrightarrow NO_3^- \uparrow$ energy

Nitrosomonas oxidizes ammonium carbonate to nitrous acid liberating energy. The nitrous acid then combines with bases in the soil forming potassium nitrite. Nitrobacter oxidizes nitrites to nitrates again liberating energy.

Neither the ammonifying nor the nitrifying bacteria add to the total quantity of combined nitrogen in the soil. The ammonifying bacteria convert amino acids into ammonia. The process is called ammonification. The nitrifying bacteria convert nitrogen from the unavailable form of ammonium salts to the available nitrates. This process converting unavailable ammonium salts into available nitrates is called nitrification.

(c) Nitrogen fixing bacteria: The nitrogen-fixing bacteria are unique in tapping a source of nitrogen not available to most other plants. This process of nitrogen transformation is called nitrogen fixation.

(i) ***Azotobacter beijerinckia*** **(aerobic forms) and** ***Clostridium*** **(anaerobic)** live free in the soil: They take gaseous nitrogen from the air present between the soil particles. The nitrogen combines with other elements forming organic nitrogenous compounds. These compounds are assimilated by the bacteria. In due course these bacteria die and their dead bodies containing nitrogenous compounds are decomposed by another type of bacteria called the bacteria of decomposition. During decomposition ammonia is produced. The nitrifying bacteria convert this ammonia first into nitrites and finally into nitrates. Nitrates constitute the form of nitrogen needed by the green plants.

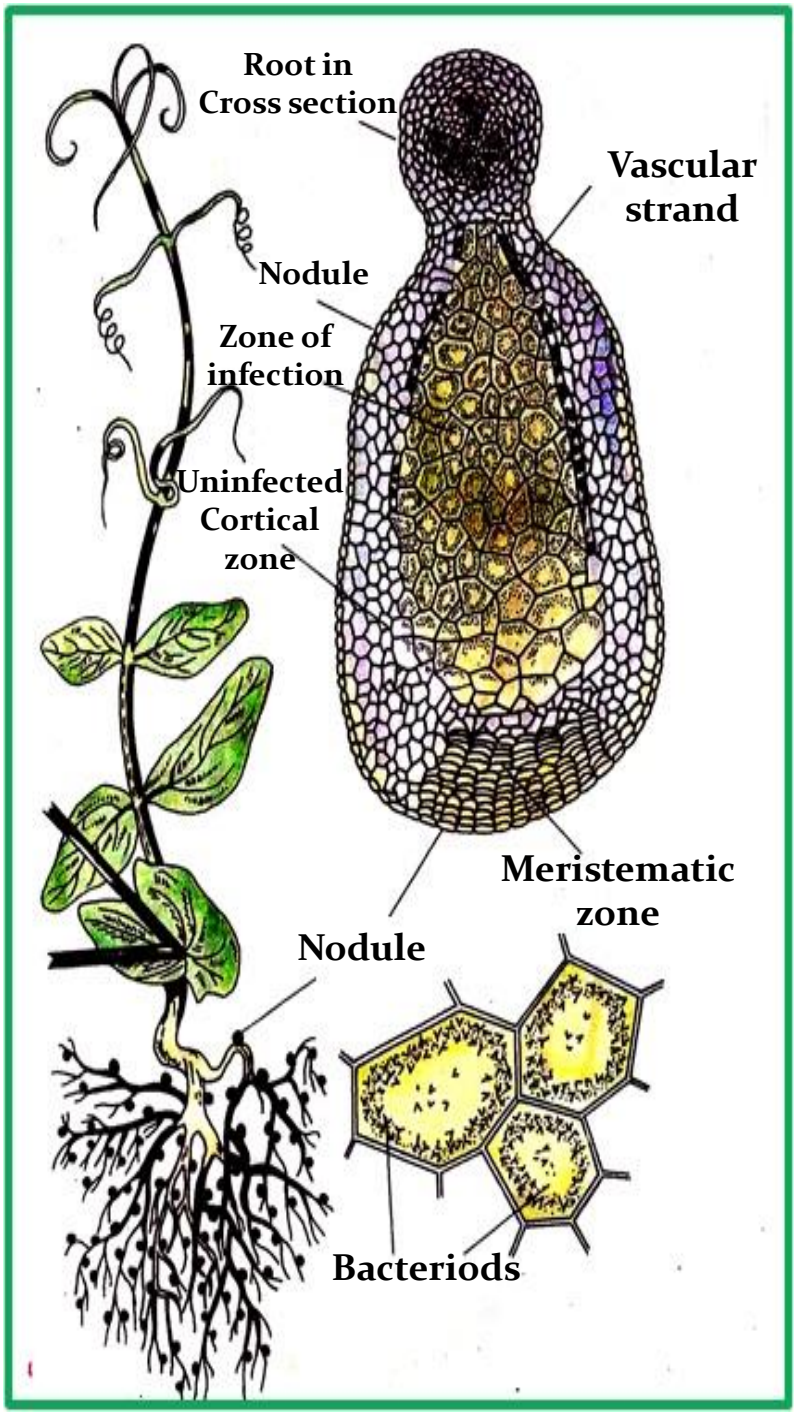
(ii) ***Rhizobium leguminosarum*** **(syn.** ***Bacillus radicicola*****)** is another nitrogen-fixing bacterium**:** It lives in the roots of such plants as Pea, Bean, Medicago and others. All these belong to the Pea family (Leguminoseae). Besides the legumes, the nodules are found on the roots of *Alnus glutinosa*, *Casuarina*, species of *Coriaria* and a few others.

- The symbiont in non- leguminous plants is a member of Plasmodiophorales. The presence of bacteria in the roots causes the formation of little nodules. In Pavetta indica the bacterial nodules are formed on the leaves.

- These nodules or the tubercles are the homes of millions of these bacteria. They have the ability to take up free nitrogen of the air and convert it into nitrogen compounds.

- They give to the host the nitrogen compounds and receive in return carbohydrates manufactured by the host plant. This association is an excellent example of symbiosis. Neither Rhizobium nor the legume root alone can fix nitrogen.

- The legume roots secrete substances which attract bacteria on to their surface. The bacteria, in turn, secrete a growth hormone which causes the root hairs to curl.
- The cocci enter the curled root hairs. They grow in the root hair in the form of a continuous thread-like mass which finally reaches the root cortex. In this way many of the cortical cells become filled with a dense mass of these bacteroids.
- Their presence in the cortical cell serves as a stimulus causing abnormal growth. The cortical cells around the infection divide and redivide and grow to form a nodule. A nodule comprises a central mass of cells full of bacteroids.
- Around this zone of infection are a few cell layers thick of bacterial free cortical zone. At the apex of the nodule is the meristematic region and a vascular strand at its base.
- Within the host cells the cocci feed on the carbohydrates and other foods and undergo a change in their form. They become V, T or Y shaped. The core of the nodule is red owing to the formation of red respiratory pigment haemoglobin.



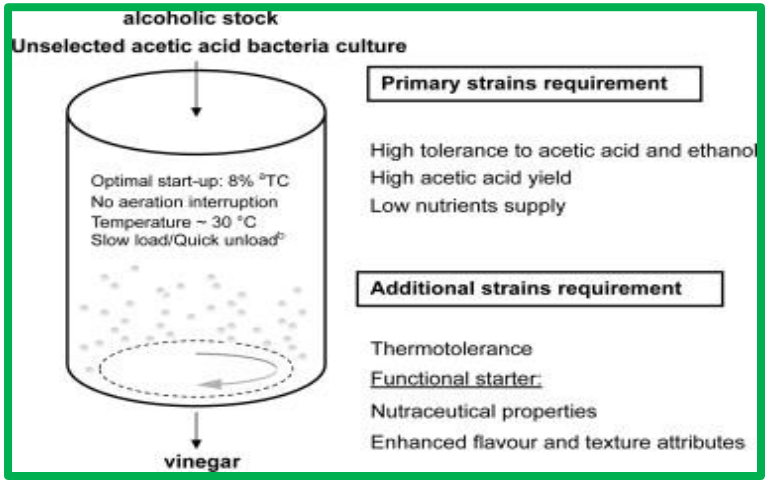
List of Some Nitrogen Fixing Bacteria

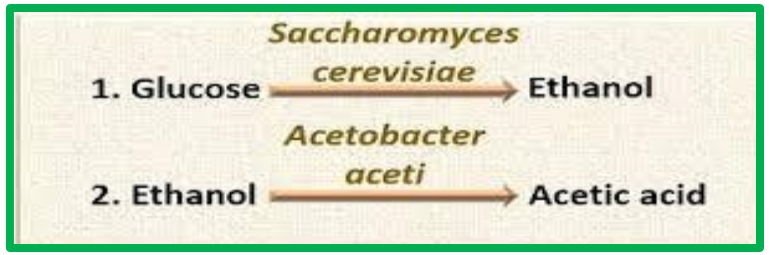
Name of Bacteria	Where Living	Mode of Life
Rhizobium leguminosum (Rhizobiaceae)	Root nodules of Legumes	Mutualistic symbiotic
Rhizobium gallicum (Rhizobiaceae)	Root nodules of legumes	Mutualistic Symbiotic
Rhizobium bangladeshense (Rhizobiaceae)	Root nodules of lentils	Mutualistic Symbiotic
Bradyrhizobium japonicum	Root Nodules of Legumes Soybean	Mutualistic Symbiotic
Frankia spp.	Nodules of Casuarina, Alnus, etc	Mutualistic Symbiotic
Azobacter agilis	Aerobic and soil inhabiting	Free living
Clostridium pneumoniae	Anaerobic and soil inhabiting	Free living

❑ Role in Industries

(i) **In dairy Industry:** Lactic acid bacteria (LAB) play an important role in the fermentation process in the dairy industry. Some lactic acid bacteria (LAB) such as *Streptococcus lactis, S. thermophilic, Lactococcus lactis, Lactobacillus plantarum, Lactobacillus casei, Lactobacillus acidophilus, Lactobacillus helveticus, Lactobacillus bulgaricus,* etc. are used to produce butter, cheese, curd, etc. These bacteria make fermentation the lactose in the milk to produce lactic acid, which helps in curd coagulation and texture formation during the cheese production.

(ii) **In vinegar industry:** Acetic acid bacteria (AAB) are used in the vinegar industry for the production of certain foods and vinegar. These are Gram-negative bacteria which belong to the family Acetobacteraceae. They can produce acetic acid during oxidative fermentation by performing oxidation reaction producing vinegar as a byproduct e.g., *Acetobacter aceti, A. cerevisiae, A. malorum, A. oeni, A. pasteurianus, A. pomorum, Gluconacetobacter entanii, G. liquefaciens, G. oxydans, Komagataeibacter europaeus, K. hansenii, K. intermedius, K. Medellinensis, K. oboediens, K. xylinus.*





(iii) In the Production of Vitamins: *Lactococcus lactis, Lactobacillus gasseri, Lactobacillus reuteri, Pseudomonas denitrificans, Clostridium butylicum* and *Bifidobacterium adolescentis.* They are able to synthesize vitamin K and B vitamins, such as biotin, nicotinic acid, cobalamin, panthotenic acid, folates, pyridoxine, riboflavin and thiamine, etc. Among these bacteria, Pseudomonas denitrificans is used to produce Cobalamin (Vitamin B_{12}) while Clostridium butylicum is used to synthesize Riboflavin.

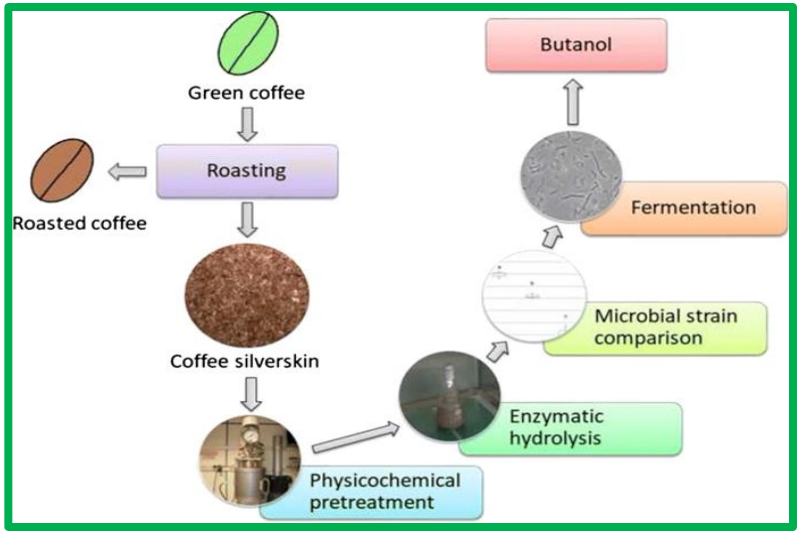
(iv) In Fiber Retting: Microbiological processes are used for discharge of the fiber. In this case, there are many bacteria help in the retting of jute, hemp and flax fibers. These bacteria grow under low oxygen condition, which can cause hydrolysis of the pectic substances that help to blind the fibers with the stem and make easy for the discharge of the fibers. The following list shows some notable bacteria species which play an important role in the process of fiber retting. E.g., *Achromobacter parvulus, Aerobacter cloacae, Aerobacter aerogenes, Bacillus brevis, Bacillus cereus, Bacillus megaterium, Bacillus sphaericus, Bacillus subtilis, Clostridium butylicum, Clostridium beijerinckii, Clostridium saprogenes, Clostridium perenne* etc.

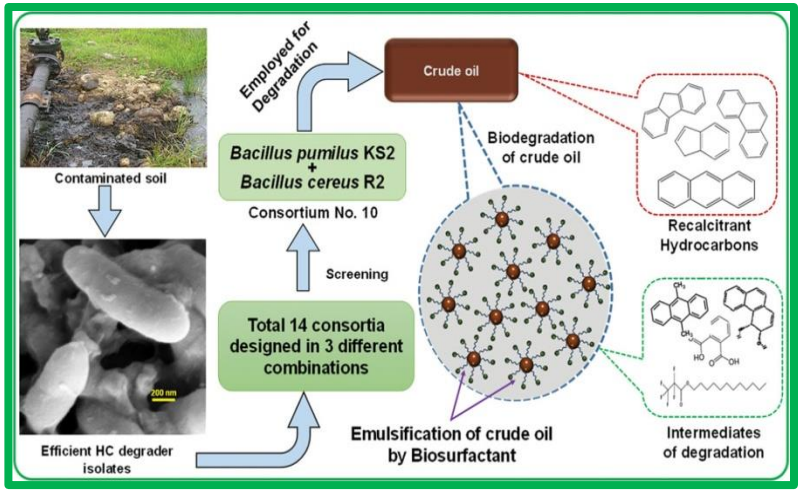
Name of Bacteria	Vitamin	Yield (mg/l)
Clostridium acetobutylicum	B_2 (Riboflavin)	0.097
C. butylicum	B_2 (Riboflavin)	0.120
Mycobacterium smegmatis	B_2 (Riboflavin)	0.060
Bacillus megaterium	B_{12}(Cobalamin)	0.51
Streptomyces olivaceus	B_{12}(Cobalamin)	3.31
Butyribacterium rettgeri	B_{12}(Cobalamin)	5.00
Micronospora sp.	B_{12}(Cobalamin)	11.5
Propionibacterium freudenreichii	B_{12}(Cobalamin)	19.0
P. shermanii	B_{12}(Cobalamin)	35.0
Pseudomonas denitrificans	B_{12}(Cobalamin)	60.0

(v) In Butanol and Acetone Production: In this case, *Clostridium acetobutylicum* is the most well-known and widely used species for the production of Butanol and acetone as a commercial basis. *Clostridium beijerinckii* is also used to produce Butanol and acetone with excellent results.

(vi) For Curing of Tea and Tobacco: Tea and tobacco are cured to give particular taste, flavor or smell by using bacteria, E.g., *Bacillus megatherium* and *Micrococcus candisans* which are used in the curing and fermentation of tea and tobacco leaves for commercial purposes.

(vii) In the Degradation of Petroleum: Hydrocarbon contamination is one of the major environmental problems today. It occurs due to the accidental releases of petroleum products from the petrochemical industry, oil tankers, ships, etc. There are many indigenous microorganisms which live in water and soil, and they can eliminate hydrocarbon contaminants. The following bacteria species can degrade hydrocarbon pollutants from crude oil: *Pseudomonas fluorescens, P. aeruginosa, Bacillus subtilis, Alcaligenes* sp., *Acinetobacter lwoffi, Flavobacterium* sp., *Micrococcus roseus, and Corynebacterium* sp.





❑ Role in Medical field

(i) **Source of Antibiotics:** Many bacteria are used in the pharmaceutical industry for the production of antibiotics, probiotics, drugs, vaccines, starter cultures, insecticides, medically-useful enzymes, etc.

❖ Bacteria are also used in the manufacture of vaccines. These vaccines are used against infectious diseases such as whooping cough, diphtheria, typhoid fever, tetanus, and cholera.

Name of bacteria	Antibiotics	Action
Bacillus subtilis	Bactracin	Syphilis, Lymphonema
Bacillus polymyxa	Polymixin	Antifungal
Streptomyces rumosus	Teramycin	Intestinal and Urinary Infections
Streptomyces griseus	Streptomycin	Pneumonia, Meningitis, Tuberculosis
Streptomyces fradiae	Neomycin	Hepatic encephalopathy, skin infections, ear infections
Streptomyces venezualae, S. lavendulae	Chloramphenicol, Chloromycetin	Typhoid, Whooping cough, Urinary Infections, A typical Pneumonia
Micromonosopora purpurea	Gentamycin	Effective against Gram (+) bacteria
Streptomyces erythreus	Erythromycin	Typhoid, Common Pneumonia and Diphtheria, Whooping Cough, etc.
Streptomyces aureofaciens	Tetracyclines	Whooping Cough, Viral pneumonia, and Eye infections.
Aspergillus fumigatus	Fumagillin	Salmonella and Shigella.
Penicillium chrysogenum, P.notatum	Pencillin	Gnonorrhea, Rheumatic Fever Tonsilitis, Sore Throat, some Pneumonia types.

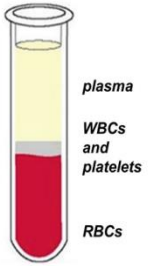
(ii) Preparation of Serums and Vaccines:

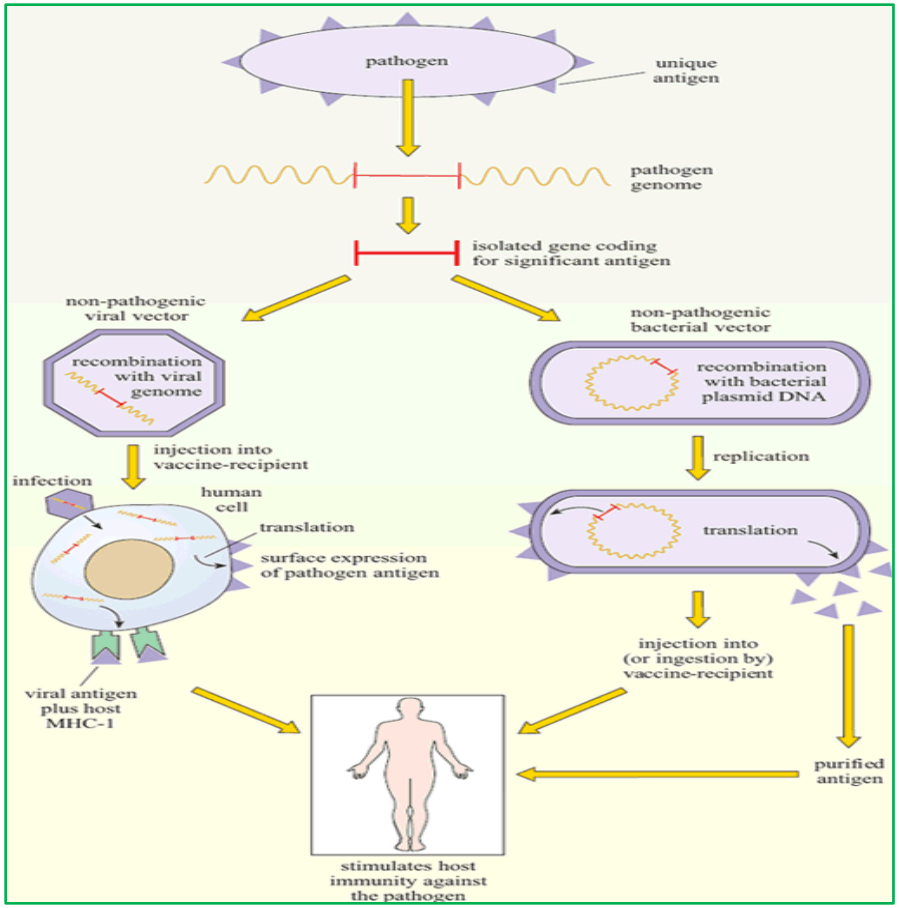
Serums are used in advance as a therapeutic measure of diseases such as diphtheria, lockjaw, pneumonia, etc. Vaccines are commonly used to make people immune to diseases like typhoid, small-pox, cholera, scarlet fever, etc.

- In the preparation of serums, small doses of bacterial toxins are injected into the blood of animals. To combat or neutralize the bacterial poisons, the body of the animal produces antibodies. The blood of the animal is then withdrawn. Impurities such as blood corpuscles and other solid matter are removed from the blood. The clear blood liquid containing the antibodies is the serum. It is used as weapon to combat diseases caused by these bacteria.

- To produce vaccines dead or weakened disease producing bacteria or their diluted poisons (antigens) are directly injected into a man to cause a disease in a mild form. As a reaction the host is stimulated to form antibodies.

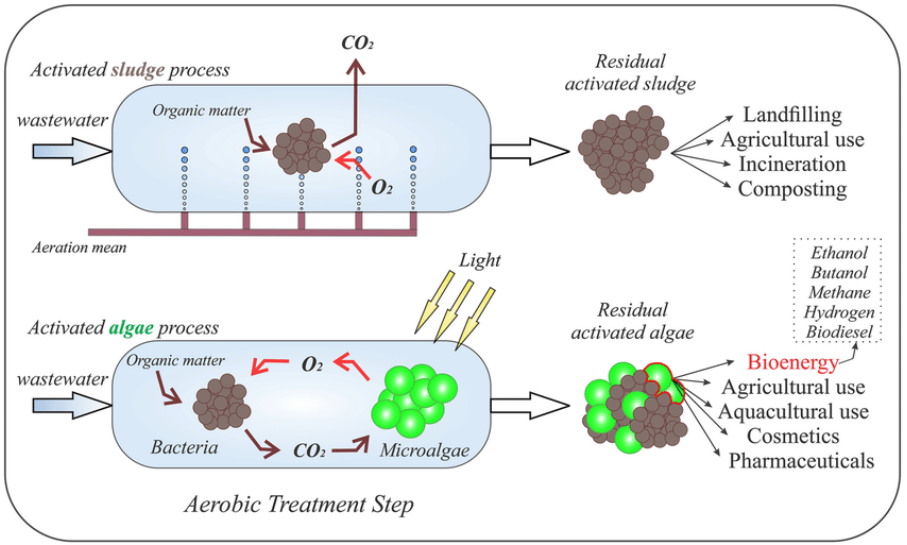
- The latter may remain for years in the body of the host imparting immunity against the same type of bacteria which may later enter his body.

PLASMA	SERUM
	
• anti-coagulants are needed for purification	• anti-coagulants are not needed
• it can be prepared as soon as it has been mixed thoroughly	• 30 minutes delay for a clot formation
• fibrinogen is present	• fibrinogen is absent
• platelets and cells (WBCs) can contaminate the liquid fraction	• cleaner sample, depleted of cells and cell remnants, but latent clotting can lead to fibrin formation
• composition of ions is representative of the circulating blood	• clot retraction elevates potassium level relative to its plasma value
• considered less stable (especially during longer storage)	• considered more stable – the gold standard for biobanking



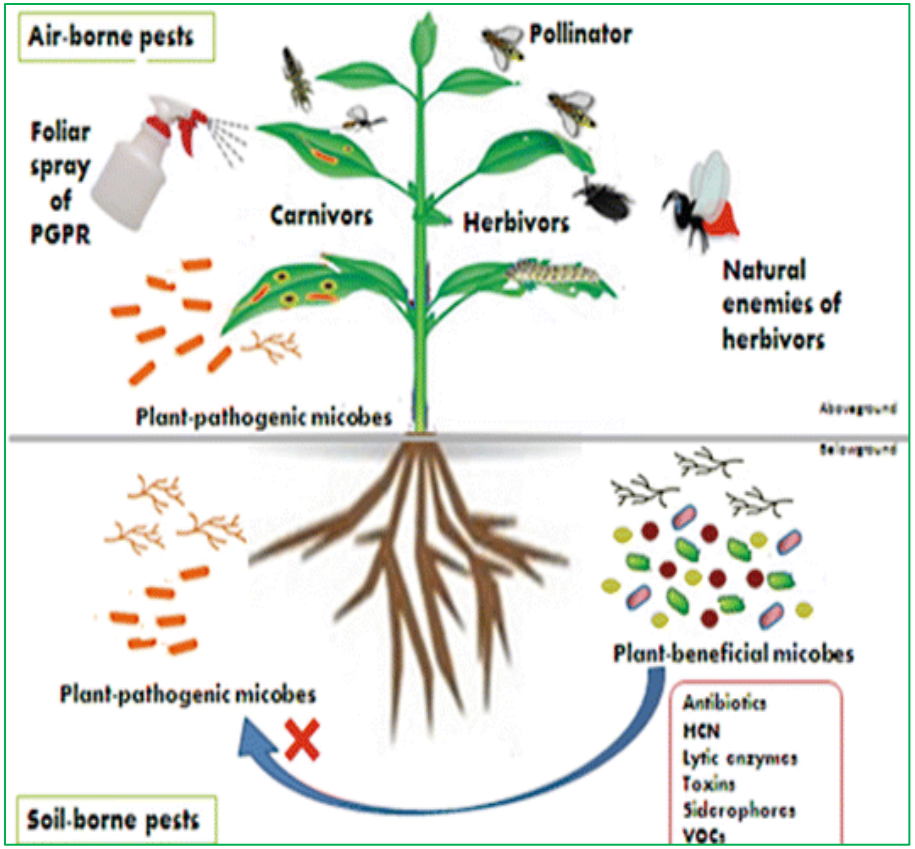
❑ Role in Wastewater Treatment

❖ There are many well-known bacteria which play an essential role in keeping sewage clean. In this case, putrifying bacteria treat and purify the wastewater and make it less harmful to our surrounding environment. These bacteria work under the anaerobic condition to remove the solid and semi-solid constituent of sewage.



❑ In Biological Control of Insects

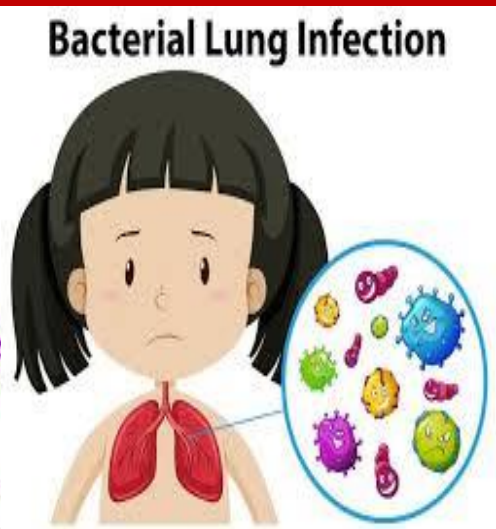
❖ It is the process for controlling different types of pests like insects, weeds, mites, and plant diseases by using other organisms. These microbial insecticides are essentially nonpathogenic and non-toxic to humans, wildlife, and other organisms. *Bacillus thuringiensis* is more effective to control *Aedes aegypti* while *B. sphaericus* strain is effective to control *Culex quinquefasciatus*. In this case, *Bacillus thuringiensis* secrete proteinaceous substances which are highly toxic to caterpillars and insects under the order Lepidoptera.

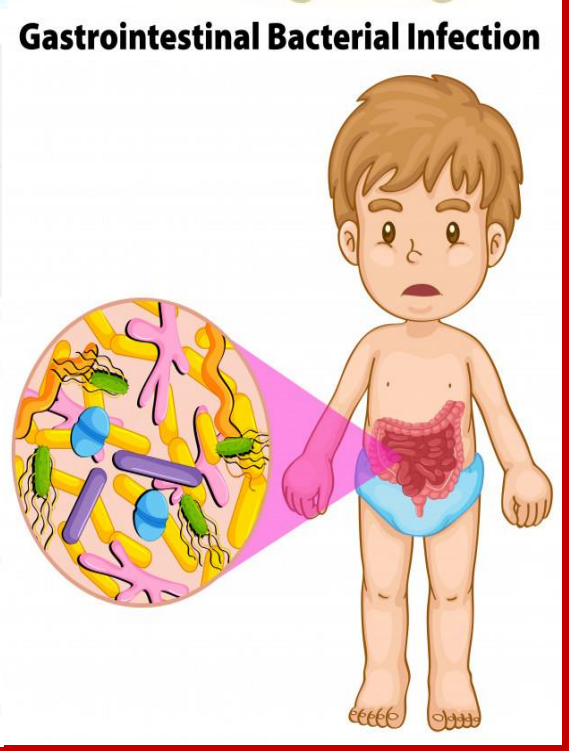


List of Some Bacteria Used as Bio Control Of Insects

Name of Bacteria	Product Name	Uses
Bacillus thuringiensis var. kurstaki	Bactur®, Caterpillar Killer®, Bactospeine®, Bioworm®, Javelin®, Dipel®, Futura®, Thuricide®,SOK-Bt®, Tribactur® etc	Effective for foliage-feeding caterpillars and Indian meal moth of stored grain.
Bacillus thuringiensis var. israelensis	Aquabee®, Bactimos®, Gnatrol®, LarvX®, Skeetal®, Mosquito Attack®, Vectobac®, Teknar®,	Effective against larvae of Aedes and Psorophora mosquitoes (Psorophora ciliata), black flies, and fungus gnats only.
Bacillus thuringiensis var. tenebrinos	Foil®, M-Track®, M-One®, Trident®, Novardo®	It is highly effective against larvae of Colorado potato beetle and the elm leaf beetle(Xanthogaleruca luteola).
Bacillus thuringiensis var. aizawai	Certan®	It is used only for control of wax moth infestations in honeybee hives.
Bacillus popilliae and Bacillus lentimorbus	Grub Attack®	Effective against larvae (grubs) of Japanese beetle
Bacillus sphaericus	Vectolex CG®, Vectolex WDG®	Effective against larvae of Culex, Psorophora, and Culiseta mosquitos, larvae of some Aedes spp.

HARMFULL ACTIVITIES OF BACTERIA





❑ Role in Food Spoilage

- Some bacteria cause food Spoilage. *Micrococcus* can cause vegetable spoilage, *Pseudomonas, Clostridium* can cause deterioration of meat while *Enterobacter* causes decay of syrup, *Acetobacter* can decay of orange.
- *Streptococcus, Micrococcus* and *Lactobacillus* also can cause decay of milk and different milk products.
- Sometimes foods are poisoned by the bacteria like *Streptococcus aureus* and *Clostridium botulinum*. *Clostridium botulinum* causes botulism disease by producing exotoxin showing the symptoms like double vision, respiratory disturbances, and swelling of the tongue. By releasing exotoxins in foods which makes the food unsuitable for the consumption of human being.
- Under favourable temperature and conditions, bacteria grow in food materials and change the appearance, flavour and smell of food. By consuming those foods, different types of diseases such as gastroenteritis, dysentery, etc. are exposed, even death may occur.

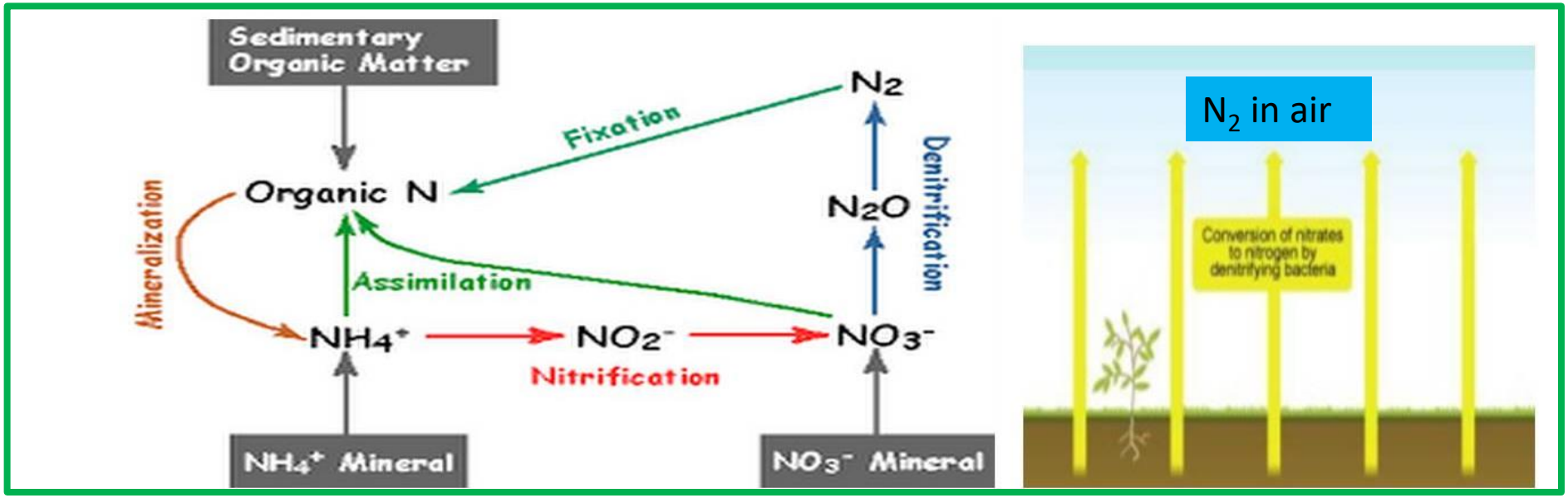
❑ Role in Water Pollution

- ❖ Water is polluted by different bacteria makes the water unsuitable for drinking. Those polluted water are transmitted by drinking and can cause diseases like cholera (*Vibrio cholera*), typhoid (*Salmonella typhi*) and bacillus dysentery (*Shigella dysenteriae*).

❑ Role in Reduction of Soil Fertility

- ❖ Moist soil-inhabiting bacteria are capable of transforming soil nitrates into gaseous nitrogen. This process is called denitrification, and those bacteria are called denitrifying bacteria.

- ❖ *Pseudomonas, Micrococcus, Thiobacillus, Achrobacter, Thiobacilus, Micrococcus, Achrobacter, Bacillus denitrificus* etc. convert nitrates of the land into gaseous nitrogen; as a result, a good loss of nitrogen occurs from the soil. Soils deficient in oxygen are also favourable for the activity of this type of bacteria.



❑ Role in Diseases

❖ Many parasitic bacteria induce diseases in plants and animals, including human.

Name of Pathogen	Diseases	Site of infection
Pathogens for man		
Salmonella typhi	Typhoid	Alimentary canal of man
Vibrio cholerae	Asiatic cholera	Intestinal tract of man
Mycobacterium tuberculosis	Tuberculosis	Lungs of man
Mycobacterium leprae	Leprosy	Skin of man
Diplococcus spp.	Pneumonia	Lungs of man
Corynobacterium diptheriae	Diptheria	Throat of man
Streptococcus sp.	Rheumatism	Joints tendons, ligaments, bones, and muscles
Clostridium septicum	Gas gangrine	Muscle tissue
Clostridium tetani	Tetanus	Blood vascular system of man
Bacillus dysenteriae	Dysentery	Intestinal tract of man
Nesseria gonorrhoea	Gonorrhea	Urethra, rectum or throat

Name of Bacteria	Diseases	Site of Infection
Animal Pathogens		
Bacillus antracis	Anthrax disease	Cattle
Yersinia pestis	Plague	Rodents
Coxiella burnetti	Q fever	Birds and rats
Leptospira interrogans	Leptospirosis	Dog

- ❖ Diseases cause by different types of bacteria in plants decrease the yield of crops. They cause diseases of our economic plants, domesticated animals and man. T.J. Burrill in 1878 first gave the information that bacteria cause plant diseases.

- ❖ There are more than 170 species of bacteria which cause plant diseases. Usually they are rod-like and non-spore forming. Many of them have flagella. The bacteria gain entry into the host through wounds or natural openings such as stomata, lenticels, hydathodes.

Name of Bacteria	Diseases	Site of Infection
Plant Pathogens:		
Streptococcus scabies	Scab disease of potato	Potato tuber
Corynebacterium rependonicium	Ringrot disease of potato	Potato tuber
Xanthomonas campestris	Black rot disease of cabbage	Young branches, leaves and fruits of citrus
Erwinia atroseptica	Black rot disease of potato	Stem and tuber of potato
Erwinia amylovora	Pear diseases(Pyrus)	Vascular tissue of pear
Pseudomonas maculicola	Cauliflower spot disease	Cauliflower
Pseudomonas solanacaerum	Wilt disease of potato	Potato, tomato
Bacterium stewartii	Wilt disease of corn	Vascular tissue of corn
Agrobacterium rhizogens	Hairy root disease of apple	Meristematic tissue of apple

- ❖ **The bacterial diseases of plants belong to the following categories:**

- **Wilt diseases:** caused by blocking of the vessels of host plant by masses of bacteria. The common example of this category are the wilt diseases of potato, cucumber, water melon and eggplant.

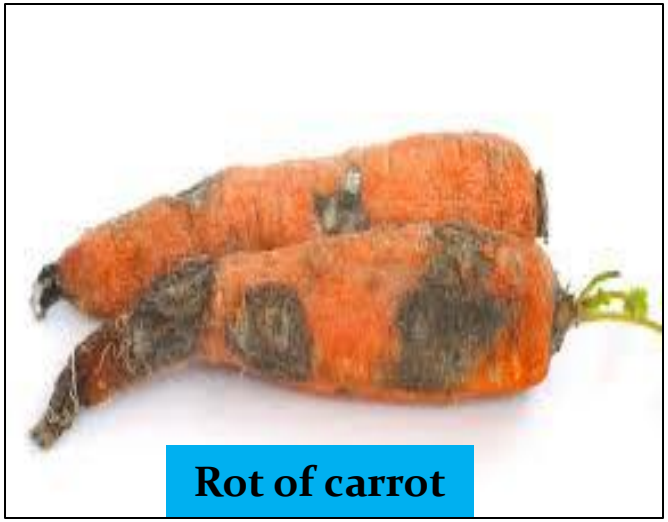
- **Crown gall and Hairy root diseases:** These are due to overgrowth or hyperplasia. The crown gall of beets and hairy root of apple are the examples.
- **Necrotic blights, leaf spots and rots:** caused by killing of parenchyma cells. Fire blight of apple, and pear and soft rot of carrot and turnip are the common examples. The following Table 3 gives a list of some important disease-causing bacteria, host plants and diseases.


Wilt


Crown gall


Necrotic blight


Leaf spot


Rot of carrot


Black rot of potato

KEY POINTS OF THE LECTURE

- Bacteria are single-celled microscopic organisms which can live in different types of environment and survive in extreme conditions.
- They contain high protective coating in their body, which enhances to live any severe conditions.
- Many of them are positively beneficial. Several others are neither harmful nor beneficial. Only a very small are harmful. The bacteria performs the two type of activities; Beneficial and harmful.
- Bacteria show positive impact on agricultural practices. They help to maintain and sustain the soil fertility.
- Some other bacteria can decompose dead leaves, release CO_2 and nutrients in the environment, which is essential for the plant's growth.
- Bacteria are the main decomposers and a valuable factor of various bio geo chemical cycle.
- Some bacteria play and important role in the nitrogen cycle of the earth.
- Bacteria play an important role in industrial activities such as dairy, vinegar, production of vitamin, fiber retting, curing tea and tobacco and degradation in petroleum.
- Many bacteria are used in the pharmaceutical industry for the production of antibiotics, probiotics, drugs, vaccines, starter cultures, insecticides, medically-useful enzymes.
- They are helpful in the preparation of serums and vaccines against various diseases.

KEY POINTS OF THE LECTURE

- Bacteria are also helpful in waste water treatment and biological control of insects.
- Many bacteria live in the stomach and mouth of a human. They are also found in soil, water, food and surface areas of our environment.
- There are many bacteria which live in the digestive system or gut of the human body. They help digestion of food and make the body healthy.
- Besides these, many bacteria show harmful effects on plants, animals and human being.
- Some bacteria cause food Spoilage resulted food poisoning in human and animals.
- Under favourable temperature and conditions, bacteria grow in food materials and change the appearance, flavour and smell of food. By consuming those foods, different types of diseases such as gastroenteritis, dysentery, etc. are exposed, even death may occur.
- Water pollution by the different bacteria makes the water unsuitable for drinking.
- Moist soil-inhabiting bacteria are capable of transforming soil nitrates into gaseous nitrogen. This process is called denitrification, and those bacteria are called denitrifying bacteria.
- Diseases cause by different types of bacteria in plants decrease the yield of crops.
- There are more than 170 species of bacteria which cause plant diseases. Wilt, crown gall, Hairy root, necrotic blights, leaf spots and rots diseases are some common bacterial diseases of plants.

TERMINOLOGY

- **Acellular:** not made of cells
- **Antibiotics:** A class of drugs that inhibit or kill microorganisms, typically bacteria.
- **Antibodies:** Antibodies are specialized proteins that are either released into the blood or located on the surface of white blood cells. They target material identified as foreign to the body, like viruses or dangerous bacteria, and mark it for destruction.
- **Bacteria:** Much larger than viruses, bacteria are a diverse group of single-cell microorganisms that display a wide variety of shapes, including rods, spirals, or spheres. Bacteria divide and reproduce themselves through a process called binary fission.
- **Cell:** The smallest structural unit of a living organism. Cells are often called the "building blocks of life." Not all cells look the same, and different types of cells have different functions and express different proteins.
- **Disease:** With many origins, a disease is a condition that causes damage to the cells and the function of a living organism.
- **Enzyme:** Protein molecules created by cells that are vital to biochemical actions. They typically have very specific purposes and interact with other proteins or genetic material to carry those actions out.
- **Gastrointestinal tract:** From mouth to rectum, the gastrointestinal tract is the system of the body that ingests, digests, absorbs, and excretes food.
- **Habitat:** The physical environment, or geography, in which an organism or microorganism lives.
- **Host:** An organism in or on which another organism lives. Parasites that live on or in a host often cause disease or damage, though not all do.

TERMINOLOGY

- **Immune system:** A highly complex network of tissues, cells, organs, and molecular signals, the immune system protects living organisms against invasion of foreign particles or pathogens.
- **Infection:** When microbes penetrate or enter a living organism and replicate. During infection, symptoms arise from both the infectious agent and the immune system's response to it.
- **Microbe:** Invisible to the naked eye, microbes (also called microorganisms) are visible with a microscope. A microbe could be a fungi, algae, bacteria, or other small living organism.
- **Parasite:** Residing on or in a living organism, parasites cause damage and disease by drawing nutrients from its host.
- **Pathogen:** A disease-causing microorganism that is sometimes called a germ.
- **Probiotics:** Microorganisms used in food and other products intended to bolster health.
- **Symbiotic (symbiosis):** The reliance of two organisms upon each other to stay alive is called a symbiosis. Symbiosis is also called mutualism, a relationship between two lifeforms in which both organisms benefit.
- **Symptom:** As an indicator of disease, illness, or dysfunction, there are many kinds of symptoms.
- **Toxin:** Produced by animals, plants, and microorganisms, toxins are substances that cause cellular and other damage when ingested, absorbed, or breathed in.
- **Vaccine:** A compound, structure, virus, or bacteria used to protect someone from a dangerous pathogen, vaccines are used in immunization programs to provide protection against infectious agents.

SOME QUESTIONS RELATED TO THE LECTURE

- **Question 1:** Write a detail note on economic importance of bacteria in daily life.
- **Question 2:** What is the role of bacteria in agriculture.
- **Question 3:** What are the role of bacteria in industrial use.
- **Question 4:** What do you understand by bacterial decay and decomposition?
- **Question 5:** Write a detail note on nitrogen cycle at the atmosphere.
- **Question 6:** Write a note on symbiotic bacteria.
- **Question 7:** Write a detail note on bacteria in vitamin production.
- **Question 8**: What is the role of bacteria in medicine.
- **Question 9:** What is the role of bacteria in bio control of insects?
- **Question 10:** Write a detail note on harmful activities of bacteria.
- **Question 11:** What do you understand by role of bacteria in human diseases?
- **Question 12:** What do you understand by denitrification? How it is a harmful process for soil.
- **Question 13:** Write a short note on relationship between water and the bacteria.

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