

MICROBES IN HUMAN WELFARE

SYLLABUS

Microbes in human welfare: In household food processing, industrial production, sewage treatment, energy generation and as biocontrol agents and biofertilizers.

KEY CONCEPTS

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.
- * A small amount of curd added to the fresh milk as inoculum or starter contain millions of LAB, which at suitable temperatures multiply, thus converting milk to curd, which also improves its nutritional quality by increasing vitamin B₁₂.
- * In our stomach too, the LAB play very beneficial role in checking disease causing microbes.
- * The dough, which is used for making foods such as dosa and idli is also fermented by bacteria. The puffed-up appearance of dough is due to the production of CO₂ gas.
- * Similarly the dough, which is used for making bread, is fermented using baker's yeast (*Saccharomyces cerevisiae*).
- * A number of traditional drinks (e.g. 'Todi' prepared from sap of palms) and foods are also made by fermentation by the microbes.
- * 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.

Different varieties of cheese are known by their characteristic texture flavour and taste, the specificity coming from the microbes used. For example, the large holes in 'Swiss cheese' are due to production of a large amount of CO₂ by a bacterium named *propionibacterium sharmani*.

The 'Roquefort cheese' are ripened by growing a specific fungi on them, which gives them a particular flavour.

Cheese : Cheese is mainly two different types.

I. Unripened cheese : Ripened from outside-soft

Ripened cheese : It is hard and ripened externally as well as internally.

Manufacturing cheese involve following steps.

(i) Milk is inoculated with starter culture of bacteria - *Streptococcus lactis* or *S.cremoris* and warmed at 38°C. If higher temperature (50°C or more) then *S.thermophilus* combined with *Lactobacillus lactis*, *L.bulgaricus* or *L.helveticus*.

When a certain acidity is reached in milk by the activity of species of bacteria, then rennet enzyme is added. Curdling of milk occurs within half an hour to one hour.

(iii) The curd is removed and liquid separates out which is called whey [contain 93% water and 5% Lactose).
 Lactose of whey is used for the manufacture of **Lactic acid - First fermented acid**.
 If the cheese is used at this stage is called **cottage cheese (unripened stage)**.

(iv) The salts mixed with cottage cheese and put into the frames and pressed so as to allow removal of whey.
 Salts hastens the removal moisture and prevent the growth of undesirable microbes. The frames are removed as soon as the cheese has set sufficiently to maintain its shape. The ripening period varies from 1-16 months but which is very tasty and nutritious. This is hard and ripened cheese contains about 20-30% fats, 20-35% proteins and small amount of minerals and vitamins. (Cheese which prepared at homes with the help of lemon juice is called **Raw cheese**). Nearly 400 varieties of cheese available which can be classified into following type

Type of Cheese	Micro Organisms used
1. Soft	Camembert <i>Penicillium camemberti</i>
2. Semi-hard	Roquefort <i>Penicillium roqueforti</i>
3. Hard	Swiss <i>Propionibacterium sp</i>

Yoghurt:

- * For production of yoghurt pasteurized milk is inoculated with a mixture of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* and its lactose is fermented by keeping it at 40°C.
- * The peculiar or characteristic taste and flavour of yoghurt is due to presence of lactic acid and acetaldehyde.
- * Curdling or coagulation of milk is also caused by lactic acid which is formed.

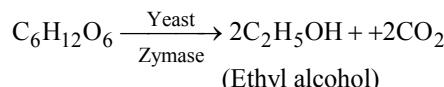
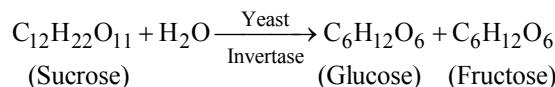
MICROBES IN INDUSTRIAL PRODUCTS

- * In industries, microbes are used to synthesise a number of products valuable to human beings.
- * Beverages and antibiotics are some examples.

- * Production on an industrial scale, requires growing microbes in very large vessels called **fermentors**.

Fermented Beverages

- * Louis Pasteur showed in the middle of nineteenth century that beer and butter milk are product of fermentation brought about by **yeast**.
- * It is a microscopic single celled organism- *Saccharomyces cerevisiae*.
- * Presently however yeast product for human and animal consumption are produced on commercial scale.
- * Alcohol was the first product of ancient biotechnology.
- * Baker's yeast is generally utilized during the preparation of food materials to increase the taste of food, flavour in food and nutrients in food. It is also utilized as **leavening agent**.
- * By the incomplete degradation of complex organic compounds [sucrose] by yeast fermentation, alcohol is formed.



- * Some other common products of yeast fermentation are
 - (i) **Beer** : It is produced from *Hordeum Vulgare* (Barely) malt and alcohol content is 3-6%
 - (ii) **Wine** : Produced from grapes, alcohol content is 10-20%.
 - (iii) **Brandy** : Produced by distillation of wine and alcohol content is 60-70%
 - (iv) **Gin** : Produced from European Rye-Scale cereal.
 - (v) **Rum** : Produced from Molasses of Sugarcane and alcohol contents is 40%.

Antibiotics

- * The term was coined by Selman Waksman (1942).
- * Antibiotics are chemical substances, which are produced by some microbes and can kill or retard the growth of other (disease-causing) microbes.

- * Penicillin was the first antibiotic to be discovered 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 Penicillin after the mould *Penicillium notatum*.
- * However, its full potential as an effective antibiotic was established much later by Ernest Chain and Howard Florey.
- * This antibiotic was extensively used to treat American soldiers wounded in World War II.
- * Fleming, Chain and Florey were awarded the Nobel Prize in 1945, for this discovery.
- * Antibiotics have greatly improved our capacity to treat deadly diseases such as plague, whooping cough (*kali khansi*), diphtheria (*gal ghotoru*) and leprosy (*kusht rog*), which used to kill millions all over the globe.
- * **Antibiotics are of two types :**
 - (i) **Broad spectrum Antibiotic :** It is an antibiotic which can kill or destroy a number of pathogens that belong to different groups with different structure and wall composition.
 - (ii) **Limited spectrum (Specific) antibiotic :** It is an antibiotic which is effective only against one type of pathogens.
- * **Main sources of Antibiotic :**
The main sources of Antibiotics production are three types
 - (i) **Eubacterials :** Most of this type of antibiotic is obtained from *Bacillus* spp 70%. *Bacillus subtilis* produced more than 60 Antibiotics and from *Pseudomonas* species 30%.
 - (ii) **Actinomycetales [Ramified]:**
Streptomyces, *Micromonospora* & *streptosporangium*. From single species *Streptomyces griseus* more than 40 antibiotics have been obtained.
 - (iii) **Fungi :** *Penicillium*.

Organic acids

Some organic acids are manufactured by employing fermentation activities of Fungi and others of Bacteria.

1. For example:
2. **Citric acid :** It is obtained by the aerobic fermentation of sucrose by the fungus *Aspergillus niger*. This acid is used in medicine, flavouring extracts, food and candies; the manufacture of ink, dyeing. It is also produced by yeast.
3. **Acetic acid or Vinegar :** Vinegar production is a two step fermentation process :
 - (i) **First step :** Alcoholic fermentation of a carbohydrate in to alcohol by yeast.
 - (ii) **Second step :** Aerobic oxidation of alcohol into acetic acid by the Bacterium *Acetobacter aceti*. Venegar is a french word, meaning - sour wine, and was known to man thousands of years ago. The Vinegar is the product of microbial fermentation, was recognised by Kutzin in 1837. In 1868 Pasteur discovered it to be a result of Biological Activity.
4. Vinegar is used in various ways in homes. It is used as a condiment and for preserving pickles, canned vegetables and fruits. Medicinally, it has an important role in promoting digestion and in overcoming constipation.
5. **Lactic acid :** Produced by fermentation of corn starch, Molasses potatoes and whey by *Lactobacillus bulgaris* and *Streptococcus lactis*.
6. **Gluconic acid :** Produced from glucose by fungus like *Aspergillus*, *Penicillium* and *Mucor*.
7. **Fumaric acid :** Produced from Sugar by activity of *Rhizopus nigricans* [Bread mould]
8. **Butyric acid :** Obtained by clostidium *butylicum*.

Enzyme

Enzymes are the organic substances which enhance the rate of biochemical reactions (without themselves undergoing any change). Enzymes are also called biological catalysts or biocatalysts.

Total known enzymes 2,200 and only 1-1.5% are used.

9. **Rennet :** Manufacturing "Cheese"
Old days cheese had been prepared either using the layer of stomach of Goat or Sheep containing special enzyme-Ficin. In 1874 a Danish Chemist - Christian Hansen extracted pure rennet enzyme from Calf's stomach for industrial production of cheese.

First of all diastase enzyme was identify by payen and persoz (1933).

(ii) **Proteases** : This enzyme obtained from *Aspergillus orizae* and *Bacillus subtilis*. *Bacillus licheniformis* and utilized from the formation of detergents in detergent industry (For removing proteinous strains on clothes). The bottle juices are clarified by the use of pectinases and protease.

(iii) **Amylases** : It works on starch and used in Beer, Bread and Textiles industries.

(iv) **Amylase, Gluco amylase and Gluco isomerase** :

By the action of all these enzymes corn (maize) starch transformed into fructose corn syrup. This syrup is more sweeter than sucrose and used in beverage industry to flavour soft drinks and in baking industry to sweeten biscuits and cakes.

(v) **Tissue Plasminogen Activator (TPA) or Streptokinase** :

This enzyme utilized in medicinal field. Streptokinase produced by the bacterium *Streptococcus* and modified by genetic engineering is used as a clot buster for removing clots from the blood vessels of patients who have undergone myocardial infarction leading to heart attack.

Bioactive molecule

- * Cyclosporin A is used as an immunosuppressive agent in organ-transplant patients, is produced by the fungus *Trichoderma polysporum*.
- * Statins produced by the yeast *Monascus purpureus* have been commercialised as blood-cholesterol lowering agents. It acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

(i) Primary treatment:

- * Involves the physical removal of particles - large and small from sewage through filtration and sedimentation.
- * Initially floating debris is removed by sequential filtration.
- * The grit (soil and small pebbles) are removed by sedimentation.
- * All solids that settle form the primary sludge, and the supernatant forms the effluents.
- * The effluents are from the primary settling tank taken for secondary treatment.

(ii) Secondary treatment or 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 SEWAGE TREATMENT

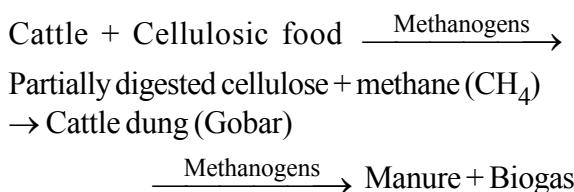
- * The waste water generated in cities and town containing human excreta. This municipal water-water is called **sewage**.
- * Treatment of waste waster is done by heterotrophic microbes naturally present in the sewage. This treatment is carried out in two stages;

MICROBES IN PRODUCTION OF BIOGAS

- * Biogas is a mixture of gases (predominantly methane) produced by the microbial activity and is used as fuel.

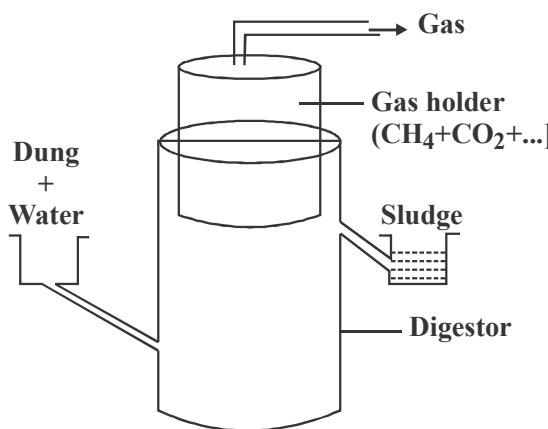
MICROBES IN HUMAN WELFARE

- * Certain bacteria grow anaerobically on cellulosic material, produce large amount of methane along with CO_2 and H_2S . These bacteria are collectively called methanogens. One common bacterium is *Methanobacterium*.
- * These bacteria present in the rumen of cattle, plays essential role in nutrition of cattle by digesting cellulose. Hence the excreta (dung) used for the production of biogas.



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 AGENT

- * Biocontrol refers to the use of biological methods for controlling plant diseases and pests.
- * Effect of use of chemical, insecticide and pesticide to control disease and pests:
 - * These chemicals are toxic and extremely harmful to human beings and animals.
 - * Polluting our environment (soil, ground water), fruits, and vegetables.
 - * Soil is polluted through use of weedicides to remove weeds.

Biological control of pest and disease:

- * 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 BIOFERTILIZERS

- * **Biofertilizers** are organisms that enrich the nutrient quality of the soil.
- * Main biofertilizers are the bacteria, fungi and cyanobacteria.

Bacteria:

- * Symbiosis - *Rhizobium* with root nodules of leguminous plants
- * *Azotobacter* and *Azospirillum* are free-living bacteria which absorb free nitrogen from soil, air and convert it into salts of nitrogen like amino acids and enrich soil nutrients.

Fungi:

- * Symbiosis- Mycorrhiza with root system of genus *Glomus* and absorb phosphorus and water from the soil for the plant growth.
- * Mycorrhiza shows the following benefits:
 - resistance to root-borne pathogens.
 - tolerance to salinity and drought.
 - Overall increase in plant growth and development.

Cyanobacteria:

- * Symbiosis - *Anabaena* in *Azolla*
- * Free living - *Nostoc*, *Oscillatoria* and Blue green algae.
- * Blue-green algae increase the soil fertility by adding organic matter to the soil.

CONCEPT REVIEW

- * **Antibiotics** : The chemicals derived from micro-organisms and used against harmful pathogens. They kill or retard the growth of pathogens. e.g., Penicillin.
- * **Anaerobic Sludge Digesters** : Large tanks where remaining part of flocs is pumped back for digestion of some bacteria and fungi by anaerobic bacteria producing biogas.
- * **Biofertilisers** : Microorganisms which produce fertilisers and enrich the soil. e.g., Bacteria, cyanobacteria and fungi.
- * **Biogas** : Useful end product of biological treatment of sewage. It consists of mixture of methane, H_2S and CO_2 .
- * **Bioactive Molecules** : Molecules produced for commercial use from microbes and used for various purposes e.g., *Trichoderma polysporum* (fungus) is used to obtain immunosuppressive agent cyclosporin A.
- * **Biochemical Oxygen Demand** : Total amount of oxygen consumed by bacteria for oxidation of organic matter present in one litre of water.
- * **Baculovirus** : Pathogens that attack insects and other arthropods. They are used to kill harmful pests and arthropods e.g., Nucleopolyhedrovirus.
- * **Biocontrol Agents** : Use of biological methods for controlling plant diseases and pests.
- * **Fermentation** : The process by which microorganisms turn organic materials such as glucose into products like alcohol.
- * **Fermenters** : A very large vessel used in industry where microbes are grown on an industrial scale.
- * **Flocs** : During secondary treatment of effluent, excessive growth of aerobic bacteria and fungi form a mass of mesh like structure called flocs.

Fermented beverages : The beverage chemicals produced by the process of fermentation e.g., Wine, beer and whisky etc.

Immuno Suppressive Agent : Chemical substances which suppress the immunity against organ transplant.

Insecticide : The chemical by which harmful insects (pests) are killed.

Lactic Acid Bacteria : Bacteria growing in milk and convert it into curd e.g., *Lactobacillus*.

Mycorrhiza : Symbiotic association of fungi with roots of higher plants to absorb water and minerals from the soil.

Methanogens : Bacteria which grow anaerobically on cellulosic material and produce methane along with CO_2 and hydrogen.

Primary Sludge : The raw form of sewage which comes for primary treatment.

Secondary (Biological) Treatment : Treatment on the primary effluent in a large aeration tank with the help of aerobic and anaerobic microbes to reduce BOD. Finally biogas is isolated and effluent is released into natural water body.

Toddy : A traditional alcohol drink derived from palm tree by fermentation and used in Southern India.

Dextrins : It is a plasma expander having 6-10% solution of dextrins which is given in case of haemorrhage, shock and dehydration and plasma transfusion.

Dextrins are soluble polyglycans or polymers of D-glucose. They are prepared either through partial hydrolysis of starch or partial polymerisation of simple sugars through microorganism *Leuconostoc mesenteroides* or Enzyme dextran sucrase. The enzyme is more useful as dextran or dextrin of suitable molecular weight can be obtained more easily.

IMPORTANT POINTS

Penicillin was discovered by Fleming.

Blue green algae (BGA) is chiefly used as fertilizer in paddy.

Green manure plants belong to leguminosae.

- * Aquatic fern which is an excellent biofertiliser is *Azolla*.
- * *Rhizobium* can use molecular nitrogen as nutrient.
- * Red pigment (leghaemoglobin) having affinity for oxygen is present in the roots of soyabean.
- * *Sesbania* is green manure/biofertilizer.
- * Insecticide pyrethrum is prepared from Chrysanthemum.
- * Mycorrhiza = Cry protein.
- * *Trichoderma hazianum* is useful for biological control of soil borne pathogens/biopesticide.
- * Ti plasmid used for making transgenic plants belongs to *Agrobacterium*.

* *Nostoc* and *legumes* helps in increasing soil fertility.

* Lactic acid bacteria grow in milk and convert it into curd increasing its nutritional value by increasing Vitamin B₁₂.

* **Composition of biogas**

S.No.	Name of gas	Chemical formula	Percentage
(1)	Methane	CH ₄	50-68%
(2)	Carbon dioxide	CO ₂	25-35%
(3)	Hydrogen	H ₂	1-5%
(4)	Nitrogen	N ₂	2-7%
(5)	Oxygen	O ₂	0-0.1%
(6)	Hydrogen sulphide	H ₂ S	Rare

* **Antibiotic produced by micro-organisms**

Antibiotic	Microbial source	Action	Discovery
Penicillin	<i>Penicillium notatum</i> and <i>P. chrysogenum</i>	Inhibits growth of <i>Pneumococcus</i> , <i>Streptococcus</i> , <i>Gonococcus</i> ; cure gonococcal infection, rheumatic fever, pneumonias diseases.	Sir Alexander Fleming (1928)
Streptomycin	<i>Streptomyces griseus</i>	Active against acid-fast and Gram-negative bacilli, cure pulmonary tuberculosis, may injure 8 th cranial or auditory nerve.	Waksman (1942)
Chloromycetin (Chloramphenicol)	<i>S. Venezuelae</i>	Broad spectrum against bacterial and rickettsial infections, viral psittacosis.	Burkholder <i>et.al.</i> (1947)
Tetracyclines			
Chlorotetracycline (Aureomycin)	<i>S. aureofaciens</i>	Broad spectrum against Gram-negative organisms; cure rickettsia and some viral diseases.	Duggar (1950)
Oxytetracycline (Terramycin)	<i>S. rimosus</i>	Broad spectrum against bacteria, rickettsia, spirochetes, some viruses typhoid and amoebiasis; non-toxic.	Discovered in 1950
Tetracycline (Archomycin)	<i>S. taxas (soil)</i>	Resemble the spectrum of chlorotetracycline.	
Dimethyl chlorotetracycline	<i>S. aureofaciens's mutant</i>	More effective against bacterial and streptococcal infections.	
Macrolides			
Erythromycin	<i>S. erythraeus</i>	Bacteriostatic to Gram-positive and some Gram-negative organisms that are resistant to penicillin; non-toxic.	Clerk (1953)
Gentamycin	<i>Micromonospora purpurea</i>	Effective against gram (+) bacteria.	
Carbomycin	<i>S. halstedii</i>		
Ravomycin	<i>S. ambofaciens</i>		
Antifungal			
Viridin	<i>Gliocladium virens</i>	Antifungal.	
Nystatin	<i>S. noursei</i>	Used adjunct to tetracyclines.	Hazen and Brown (1953)
Griseofulvin	<i>Penicillium griseofulvum</i>	Inhibits growth of most of the fungi but not of bacteria; used in ringworm treatment.	
Hamycin	<i>S. Pimpreni</i>	Fungal infection like thrush.	Hindustan Antibiotics, Poona
Actinomycetin	Actinomycetes	Some saprophytic bacteria can kill Anthrax bacterium	Pasteur and Jaubert (1877)

QUESTION BANK

EXERCISE - 1 (LEVEL-1) [NCERT EXTRACT]

SECTION - 1 (VOCABULARY BUILDER)

Choose one correct response for each question.

For Q.1-Q.4

Match the column I with column II.

Q.1 Column I (Organism) Column II (Uses)

a. <i>Lactobacillus</i>	i. Roquefort cheese
b. <i>Saccharomyces cerevisiae</i>	ii. Swiss cheese
c. <i>Propionibacterium sharmani</i>	iii. Bread
d. <i>Penicillium roqueforti</i>	iv. Milk into curd

(A) (a)–(iv), (b)–(iii), (c)–(ii), (d)–(i)
 (B) (a)–(iii), (b)–(ii), (c)–(i), (d)–(iv)
 (C) (a)–(iv), (b)–(i), (c)–(ii), (d)–(iii)
 (D) (a)–(i), (b)–(iv), (c)–(iii), (d)–(ii)

Q.2 Column I Column II
 Bioactive Substance Role

(a) Statin	(i) Removal of oil stains
(b) Cyclosporin A	(ii) Removal of clots from blood vessels
(c) Streptokinase	(iii) Lowering of blood cholesterol
(d) Lipase	(iv) Immuno-suppressive agent

(A) (a)–(ii), (b)–(iii), (c)–(i), (d)–(iv)
 (B) (a)–(iv), (b)–(ii), (c)–(i), (d)–(iii)
 (C) (a)–(iv), (b)–(i), (c)–(ii), (d)–(iii)
 (D) (a)–(iii), (b)–(iv), (c)–(ii), (d)–(i)

Q.3

Column I

(Microbes)

a. <i>Aspergillus niger</i>	i. Lacti acid
b. <i>Acetobacter aceti</i>	ii. Butyric acid
c. <i>Clostridium butylicum</i>	iii. Acetic acid
d. <i>Lactobacillus</i>	iv. Citric acid

(A) (a)–(iv), (b)–(ii), (c)–(iii), (d)–(i)
 (B) (a)–(ii), (b)–(iii), (c)–(i), (d)–(iv)
 (C) (a)–(iv), (b)–(iii), (c)–(ii), (d)–(i)
 (D) (a)–(iii), (b)–(ii), (c)–(i), (d)–(iv)

Q.4

Match the items in Column 'A' and Column 'B'

Column I

Column II

(a) Lady bird	(i) Methano bacterium
(b) Mycorrhiza	(ii) Trichoderma
(c) Biological control	(iii) Aphids
(d) Biogas	(iv) Glomus

(A) (a)–(ii), (b)–(iv), (c)–(iii), (d)–(i)
 (B) (a)–(iii), (b)–(iv), (c)–(ii), (d)–(i)
 (C) (a)–(iv), (b)–(i), (c)–(ii), (d)–(iii)
 (D) (a)–(iii), (b)–(ii), (c)–(i), (d)–(iv)

SECTION - 2 (BASIC CONCEPTS BUILDER)

For Q.5 to Q.19

Choose one word for the given statement from the list.

Fermentation, Alcohol, Statins, Ladybird, Yeast, Cyanobacteria, Mycorrhiza, Glomus, Lipases, Cyanobacteria, Aphids and mosquitoes, Activated sludge treatment, Baculoviruses, Streptokinase ; Myocardial infarction, Primary sludge, effluent, nucleopolyhedrovirus (NPV)

Q.5 The dough used for making bread is fermented by _____.

Q.6 A sewage treatment process in which a part of decomposer bacteria present in the wastes is recycled into the starting of the process is called _____.

Q.7 _____ bottle with red and black markings is useful in controlling aphids.

Q.8 Species-specific, narrow spectrum insecticidal applications are shown by _____.

Q.9 In paddy fields, ____ serve as an important biofertilisers.

Q.10 Brewer's yeast is used for ____ of malted cereals and fruit juices to produce _____.

Q.11 ____ are used in detergent formulations and are helpful in removing oily stains from laundry.

Q.12 ____ enzyme is used to remove clots from the blood vessels of patients who have undergone ____ leading to heart attack.

Q.13 ____ are produced by yeast and act by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

Q.14 During primary treatment, all solids that settle forms ____ and the supernatant forms _____.

Q.15 The ladybird beetle and dragonflies are useful to get rid of ____ and ____ respectively.

Q.16 The symbiotic association of fungi with plants is known as ____ which is formed by many members of the fungal genus _____.

Q.17 Curd is more nutritious than milk. [True / False]

Q.18 Beverages like whisky, brandy and rum are produced without distillation. [True / False]

Q.19 *Acetobacter aceti* is a source of acetic acid. [True / False]

SECTION - 3 (ENHANCE PROBLEM SOLVING SKILLS)

Choose one correct response for each question.

PART - 1 : MICROBES IN HOUSEHOLD AND INDUSTRIAL PRODUCTS

Q.20 Which one of the fungi is used for production of citric acid?
 (A) *Lactobacillus bulgaricus*
 (B) *Penicillium bulgaricus*
 (C) *Aspergillus niger*
 (D) *Rhizopus nigricans*

Q.21 *Saccharomyces cerevisiae* is used for commercial production of
 (A) butanol (B) ethanol
 (C) methanol (D) acetic acid

Q.22 Yeast is used in the production of
 (A) citric acid and lactic acid
 (B) lipase and pectinase
 (C) bread and beer
 (D) cheese and butter

Q.23 Which one of these microbes is used in the commercial production of butyric acid?

(A) *Clostridium butylicum*
 (B) *Streptococcus butylicum*
 (C) *Trichoderma polysporum*
 (D) *Saccharomyces cerevisiae*

Q.24 Which of the following bacteria convert milk into curd?
 (A) *Propionibacterium sharmanii*
 (B) *Saccharomyces cerevisiae*
 (C) *Lactobacillus*
 (D) Thermophilic bacteria

Q.25 Penicillin is the first antibiotic. It was discovered by
 (A) Alexander Fleming; 1928
 (B) Alexander Fleming; 1930
 (C) S Waksman; 1928
 (D) S Waksman; 1930

Q.26 Swiss cheese is formed by the bacterium
 (A) *Aspergillus niger*
 (B) *Lactobacillus*
 (C) *Propionibacterium shermanii*
 (D) *Penicillium roqueforti*

PART - 2 : MICROBES IN PRODUCTION OF BIOGAS AND SEWAGE TREATMENT

Q.42 What would happen if oxygen availability to activated sludge flocs is reduced?

- (i) It will slow down the rate of degradation of organic matter.
- (ii) The center of flocs will become anoxic, which would cause death of bacteria and eventually breakage of flocs.
- (iii) Flocs would increase in size as anaerobic bacteria would grow around flocs.
- (iv) Protozoa would grow in large numbers.

Choose the correct option –

(A) i, ii	(B) ii, iii
(C) i, iv	(D) iii, iv

Q.43 The primary treatment of waste water involves the removal of –

- (A) dissolved impurities
- (B) stable solid particles
- (C) toxic substances
- (D) harmful bacteria

Q.44 Activated sludge have the ability to settle quickly so that it can

- (A) be rapidly pumped back from sedimentation to aeration.
- (B) absorb pathogenic bacteria present in waste water, while sinking to the bottom of the settling-tank
- (C) be discarded and anaerobically digested
- (D) absorb colloidal organic matter

Q.45 The residue left after methane production from cattle dung is:

- (A) burnt
- (B) buried in land fills
- (C) used as manure
- (D) used in civil construction.

Q.46 BOD of waste water is estimated by measuring the amount of:

- (A) total organic matter
- (B) biodegradable organic matter
- (C) oxygen evolution
- (D) oxygen consumption.

Q.47 Which is produced during anaerobic fermentation of agricultural wastes?

- (A) Methane
- (B) CO_2
- (C) Carbon monoxide
- (D) Biogas

Q.48 By anaerobic process, the cow dung is used to produce –

- (A) propane
- (B) butane
- (C) ethane
- (D) methane

PART - 3 : MICROBES AS BIOCONTROL AGENT

Q.49 *Bacillus thuringiensis (Bt)* strains have been used for designing novel –

- (A) biofertilisers
- (B) bio-mineralisation process
- (C) bio-insecticidal
- (D) bio-metallurgical technique

Q.50 The main sources of biofertilisers are –

- (A) Protista
- (B) cyanobacteria
- (C) fungi
- (D) All of these

Q.51 The free-living fungus *Trichoderma* can be used for:

- (A) killing insects
- (B) biological control of plant diseases
- (C) controlling butterfly caterpillars
- (D) producing antibiotics

Q.52 Which of the following serve as biofertiliser in paddy fields?

- (A) *Anabaena*
- (B) *Azospirillum*
- (C) *Nostoc*
- (D) Both (A) and (C)

Q.53 Mycorrhiza does not help the host plant in:

- (A) Enhancing its phosphorus uptake capacity
- (B) Increasing its tolerance to drought
- (C) Enhancing its resistance to root pathogens
- (D) Increasing its resistance to insects.

Q.54 In rice fields biological nitrogen fixation is chiefly brought by –

- (A) lichen
- (B) brown algae
- (C) cyanobacteria
- (D) *Rhizobium*

Q.55 Which one of the following is not a nitrogen-fixing organism?

- (A) *Anabaena*
- (B) *Nostoc*
- (C) *Azotobacter*
- (D) *Pseudomonas*

Q.56 Blue-green algae are mainly used as biofertilisers in the field of which crop?

- (A) Gram
- (B) Millet
- (C) Rice
- (D) Maize

Q.57 The most important of the symbiotic nitrogen fixing bacteria, which forms nodules on the roots of legume plants is

- (A) *Aspergillus*
- (B) *Rhizobium*
- (C) *Penicillium*
- (D) *Streptococcus*

EXERCISE - 2 (LEVEL-2)

Choose one correct response for each question.

Q.1 INCORRECT statement regarding mycorrhiza?
 (A) It helps in absorption of phosphorus from the soil.
 (B) It is a symbiotic association of fungi with the roots of higher plants.
 (C) It helps the plant in developing resistance to root-borne pathogens.
 (D) None of these

Q.2 A good example of organic fertiliser, which improves phosphorus uptake is –
 (A) Actinomycetes fungi (B) *Rhizobium*
 (C) *Azospirillum* (D) None of these

Q.3 Select the incorrect statement(s) out of the following.
 (A) Secondary treatment of sewage is a physicochemical process.
 (B) Azadirachtin is an insecticide obtained from the roots of Margosa.
 (C) Free-living nitrogen fixers like *Azospirillum* and *Azotobacter* enrich the nitrogen content in soil.
 (D) Both (A) and (B)

Q.4 Which of the following options includes biofertilizers?
 (A) Cowdung manure and farmyard waste.
 (B) A quick growing crop ploughed back into the field.
 (C) *Nostoc, Oscillatoria*.
 (D) All of these.

Q.5 Which out of the following is a N_2 -fixing blue green alga?
 (A) *Anabaena* (B) *Frankia*
 (C) *Rhizobium* (D) *Azotobacter*

Q.6 Nutritionally curd is more suitable than milk. Which of the following reason not supporting to this view
 (A) It increasing vitamin B_{12}
 (B) It checks disease causing microbes
 (C) LAB convert lactose into lactic curd
 (D) It provide additional proteins

Q.7 Which of the following is not a product of distillation
 (A) Whisky (B) Brandy
 (C) Wine (D) Rum

Q.8 Find out odd one with reference to distillation
 (A) Beer (B) Wine
 (C) Champagne (D) Vodka

Q.9 Full potential of penicillin as an effective antibiotic was established by
 (A) Alexander Flemming (B) Ernest chain
 (C) Howard florey (D) Both B and C

Q.10 Cultivation of which of the following crop plant specially get benefitted by application of cyanobacteria
 (A) Maize (B) legumes
 (C) Wheat (D) Rice

Q.11 Formation of vinegar from alcohol is caused by –
 (A) *Bacillus subtilis* (B) *Clostridium*
 (C) *Acetobacter aceti* (D) *Azotobacter*

Q.12 Modern farmer's can increase the yield of Paddy upto 50% by the use of –
 (A) Cyanobacteria
 (B) *Rhizobium*
 (C) Cyanobacteria in *Azolla pinnata*
 (D) Farm yard manure

Q.13 *Bacillus thuringiensis* show their inhibitory effect on which part of the insect body
 (A) Gut (B) Respiratory tract
 (C) Nervous system (D) Circulatory system

Q.14 Which of the following biological agents are used for species specific, narrow spectrum insecticidal applications –
 (A) Adenoviruses
 (B) Nucleopolyhedrosis viruses
 (C) Retroviruses
 (D) *Trichoderma*

Q.15 Which of the following is "Clot buster"
 (A) Citric acid (B) Streptokinase
 (C) Cyclosporin (D) Statins

Q.16 Mark the correct option with respect to the composition of biogas.

(A) 50 - 70% H₂ (B) 30-40% CO₂
 (C) 95% CH₄ (D) 10% CO

Q.17 Functioning of statin is based on

(A) Competitive inhibition
 (B) Endproduct inhibition
 (C) Allosteric inhibition
 (D) Negative feed back inhibition

Q.18 Regarding to primary treatment of sewage, which of the following statement is not true

(A) It is physical treatment
 (B) It is based on filtration and sedimentation
 (C) Initially grit are removed
 (D) Effluent of primary treatment is taken for secondary treatment.

Q.19 Methanogenic bacteria are not found in:

(A) rumen of cattle
 (B) gobar gas plant
 (C) bottom of water-logged paddy fields
 (D) activated sludge.

Q.20 During secondary treatment or biological treatment which of the following do not happen

(A) Decrease in BOD
 (B) Production of organic matter by microbes
 (C) Consumption of organic matter
 (D) Increase in DO

Q.21 Activated sludge is the sedimentation product of

(A) Primary treatment (B) Secondary treatment
 (C) Tertiary treatment (D) All of these

Q.22 After secondary treatment a part of activated sludge is passed back to aeration tank as inoculum while most of the part of activated sludge passed to –

(A) Aerobic sludge digester
 (B) Tertiary treatment
 (C) Rivers and streams
 (D) Anaerobic sludge digesters

Q.23 The technology of biogas production was developed in India mainly due to efforts of

(A) IARI (B) KVIC
 (C) IPM (D) Both A and B

Q.24 Which of the following bacteria was associated with discovery of penicillin

(A) *Streptococcus*
 (B) *Staphylococcus*
 (C) *Saccharomyces cerevisiae*
 (D) *Propionobacterium*

Q.25 Which of the following is one of the advantage of application of viruses as bioinsecticides

(A) They are less effective.
 (B) They are host specific.
 (C) They are costly.
 (D) They can not obtain easily.

Q.26 In which conditions use of baculoviruses is desirable –

(A) When they are used as part of IPM.
 (B) When an ecologically sensitive area is being treated.
 (C) When beneficial insects are being conserved
 (D) All of the above

Q.27 Use of biofertilizer is the part of

(A) Inorganic farming (B) Organic farming
 (C) Energy cropping (D) Energy plantation

Q.28 Large holes in “Swiss cheese” are due to production of large amount of CO₂ by bacterium

(A) *Leuconostoc mesenteroides*
 (B) *Propionibacterium sharmanii*
 (C) *Thermococcus proteus*
 (D) *Staphylococcus thermophilus*

Q.29 Which of the following is not an advantage of mycorrhiza –

(A) Phosphorus absorptio.
 (B) Resistance to root borne pathogens
 (C) Nitrogen fixation
 (D) Tolerance to salinity and draught

Q.30 Methanogens do not produce:

(A) oxygen (B) methane
 (C) hydrogen sulfide (D) carbon dioxide.

EXERCISE - 3 (LEVEL-3)

Choose one correct response for each question.

Q.1 Select the mismatched pair out of the following.

Green manure	Botanical name
(A) Dhaincha	<i>Sesbania aculeata</i>
(B) Egyptian clover	<i>Lens esculenta</i>
(C) Cluster bean	<i>Cyamopsis tetragonoloba</i>
(D) Sunnhemp	<i>Crotalaria juncea</i>

Q.2 Select the correct statement(s) out of the following.

(A) Smoother crops are the crop plants that do not allow the weeds to grow nearby. e.g., Barley, Rye, *Sorghum* etc.

Note (Q.4-Q.6) :

- (A) Statement- 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-1.
- (B) Statement -1 is True, Statement -2 is True ; Statement-2 is NOT a correct explanation for Statement-1.
- (C) Statement-1 is True, Statement- 2 is False.
- (D) Statement-1 is False, Statement -2 is False.

Q.4 Statement 1 : Yeasts such as *Saccharomyces cerevisiae* are used in baking industry.

Statement 2 : Carbon dioxide produced during fermentation causes bread dough to rise by thermal expansion.

Q.5 Statement 1 : Curdling is required in the manufacture of cheese.

Statement 2 : Lactic acid bacteria and rennet is used for the purpose.

Q.6 Statement 1 : Sugar crops and strach crops are valuable as solar energy converters.

Statement 2 : They provide both liquid and solid fuels.

Q.7 Which of the following plants are used as green manure in crop fields and in sandy soils ?

- (A) *Crotalaria juncea* and *Alhagi comelorum*
- (B) *Clotropis procera* and *Phyllathus niruri*
- (C) *Saccharum munja* and *Lantana camara*
- (D) *Dichanthium annulatum* and *Acacia nilotica*.

Q.8 Consider the following statements.

- I. Ladybirds and dragonflies are used to get rid of aphids and mosquitoes.
- II. The bacteria *Bacillus thuringiensis* (*Bt*) are used to control butterfly.

III. *Trichoderma* sp. free living fungi, are present in root ecosystems where they act against several plant pathogens.

IV. *Rhizobium* is a symbiotic bacterium that lives in the stem of legumes.

Which of the statements given above are correct?

- (A) I, II and III
- (B) 1, III and IV
- (C) II, III and IV
- (D) II and IV

Q.9 In September 2001, which of the following was used as a bioweapon agent in America?

- (A) Botulinum
- (B) Anthrax (*Bacillus anthracis*)
- (C) Polio virus
- (D) AIDS virus

Q.10 Which of the following statement is correct ?

- (A) Cyanobacteria such as *Anabaena* and *Nostoc* are important mobilisers of phosphates and potassium for plant nutrition in soil.
- (B) At present it is not possible to grow maize without chemical fertilisers.
- (C) Extensive use of chemicals fertilisers may lead to eutrophication of nearby water bodies.
- (D) Both *Azotobacter* and *Rhizobium* fix atmospheric nitrogen in root nodules of plants.

Q.11 One of the major difficulties in the biological control of insect pest is that the –

- (A) method is less effective as compared with the use of insecticides.
- (B) predator does not always survive when transferred to a new environment.
- (C) predator develops a preference to other diets and may itself become a pest.
- (D) practical difficulty of introducing the predator to specific area.

EXERCISE - 4 (PREVIOUS YEARS AIPMT/NEET EXAM QUESTIONS)

Choose one correct response for each question.

	Microbe	Product	Application
(A)	<i>Trichoderma polysporum</i>	Cyclosporin A	immunosuppressive drug
(B)	<i>Monascus purpureus</i>	Statins	lowering of blood cholesterol
(C)	<i>Streptococcus</i>	Streptokinase	removal of clot from blood vessel
(D)	<i>Clostridium butylicum</i>	Lipase	removal of oil stains

Q.12 Select the correct group of biocontrol agents.

(A) *Bacillus thuringiensis*, Tobacco mosaic virus, Aphids [NEET 2019]

(B) *Trichoderma*, *Baculovirus*, *Bacillus thuringiensis*

(C) *Oscillatoria*, *Rhizobium*, *Trichoderma*

(D) *Nostoc*, *Azospirillum*, *Nucleopolyhedrovirus*

Q.13 Match the following organisms with the products they produce [NEET 2019]

(a) <i>Lactobacillus</i>	(i) Cheese
(b) <i>Saccharomyces cerevisiae</i>	(ii) Curd
(c) <i>Aspergillus niger</i>	(iii) Citric Acid
(d) <i>Acetobacter aceti</i>	(iv) Bread
	(v) Acetic Acid

Select the correct option.

(A) a-(ii), b-(iv), c-(v), d-(iii)

(B) a-(ii), b-(iv), c-(iii), d-(v)

(C) a-(iii), b-(iv), c-(v), d-(i)

(D) a-(ii), b-(i), c-(iii), d-(v)

Q.14 Which of the following can be used as a biocontrol agent in the treatment of plant disease? [NEET 2019]

(A) *Trichoderma* (B) *Chlorella*
(C) *Anabaena* (D) *Lactobacillus*

ANSWER KEY

EXERCISE-1 (SECTION-1&2)

(1) (A)	(2) (D)	(3) (C)	(4) (B)	(12) Streptokinase ; Myocardial infarction
(5) Yeast	(6) Activated sludge treatment			(13) Statins (14) Primary sludge, effluent
(7) Ladybird				(15) Aphids and mosquitoes
(8) Baculoviruses or <i>nucleopolyhedrovirus</i> (NPV)				(16) Mycorrhiza ; <i>Glomus</i>
(9) Cyanobacteria	(10) Fermentation, Alcohol			(17) True (18) False (19) True
(11) Lipases				

EXERCISE - 1 [SECTION-3]																				
Q	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
A	C	B	C	A	C	A	C	D	B	B	D	A	B	B	B	A	D	B	C	
Q	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57		
A	D	A	A	B	A	C	D	D	D	C	B	B	D	D	C	D	C	B		

EXERCISE - 2																				
Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	D	D	D	C	A	D	C	D	D	D	C	C	A	B	B	B	A	C	D	B
Q	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38		
A	B	D	D	B	B	D	B	B	C	A	C	A	A	D	D	A	C	D		

EXERCISE - 3											
Q	1	2	3	4	5	6	7	8	9	10	11
A	B	D	C	A	B	A	A	A	B	C	B

EXERCISE - 4														
Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	C	C	B	A	C	D	C	B	D	A	B	B	B	A

SOLUTIONS

EXERCISE-1

(1) (A) (2) (D) (3) (C) (4) (B)
 (5) Yeast (6) Activated sludge treatment
 (7) Ladybird
 (8) Baculoviruses or *nucleopolyhedrovirus* (NPV)
 (9) Cyanobacteria (10) Fermentation, Alcohol
 (11) Lipases
 (12) Streptokinase ; Myocardial infarction
 (13) Statins (14) Primary sludge, effluent
 (15) Aphids and mosquitoes
 (16) Mycorrhiza ; *Glomus*
 (17) True (18) False (19) True
 (20) (C). Citric acid is obtained through the fermentation carried out by *Aspergillus niger* and *Mucor* species on sugary syrups. Citric acid is employed in dyeing, engraving, medicines, inks, flavouring and preservation of food and candies.
 (21) (B). *Saccharomyces cerevisiae* is used for commercial production of ethanol. *S. cerevisiae* is a single celled eukaryotic budding yeast belonging to the Ascomycetes (a highly diverse group of fungi).
 (22) (C). Bread is made through fermentation by *Saccharomyces cerevisiae* or commonly called baker's yeast. Yeast species also used in alcoholic fermentation is *S. cerevisiae* (Brewer's yeast).
 (23) (A). *Clostridium butylicum* is used in the commercial production of butyric acid.
 (24) (C). Lactic Acid Bacteria (LAB) like *Lactobacillus* are added to milk. It converts lactose sugar of milk into lactic acid. Lactic acid causes coagulation and partial conversion of milk protein casein to paracaeinate. Milk is changed into curd, yoghurt and cheese.
 (25) (A)
 (26) (C). Swiss cheese is manufactured with a single strains of *Propionibacterium sharmanii* and *Propionibacterium arabinosum*. Its characteristic feature is formation of large holes due to production of large amount of CO_2 .

(27) (D). Streptokinase is used as clot-buster for removing clots from blood vessels of patients who have undergone myocardial infarction.
 (28) (B). Roquefort cheese is formed by ripening with the fungi *Penicillium roqueforti* for a particular flavour.
 (29) (B)
 (30) (B). Microorganism such as *Lactobacillus* and others commonly called Lactic Acid Bacteria (LAB). These bacteria are widely used in food fermentation because of their ability to improve flavours, texture and safety of perishable raw materials such as milk, meat and vegetables.
 (31) (D). Penicillin was the first antibiotic to be discovered by Alexander Flemming (1928). The antibiotic was however, commercially extracted by efforts of Chain and Florey. Flemming, Chain and Florey were awarded Nobel Prize in 1945.
 (32) (A). Wine and beer are produced without distillation whereas whisky, brandy and rum are produced by distillation of the fermented broth.
 (33) (B). Large holes Swiss cheese is ripened with the help of CO_2 producing (causing holes) bacterium called *Propionibacterium sharmanii*.
 (34) (B)
 (35) (B). Penicillin antibiotic was extensively used to treat American soldiers wounded in World War II.
 (36) (A) (37) (D) (38) (B)
 (39) (C) (40) (D)
 (41) (A). The sediment of settling tank is called activated sludge. A part of it is used as inoculum in aeration tanks. The remaining is passed into a large tank called anaerobic sludge digesters.
 (42) (A). Flocs are masses of bacteria associated with fungal filaments to form mesh like structures. If oxygen availability to activated sludge flocs is reduced, their rate of decomposition

of organic matter will decrease. And as the centre of flocs will become anoxic, the bacterial cells will die, thus causing breakage of flocs.

(43) (B). Primary treatment of sewage is the process of removal of small and large, floating and suspended solid from sewage through filtration and sedimentation.

(44) (A). Activated sludge should have the ability to settle quickly so that it can be rapidly pumped back from sedimentation to aeration tank.

(45) (C).

(46) (D). Degree of impurity of water due to organic matter is measured in terms of B.O.D. It is the oxygen in milligrams required for five days in one litre of water at 20°C for the microorganisms to metabolise organic waste.

(47) (D)

(48) (D). Biogas is the methane rich fuel gas produced through anaerobic breakdown and fermentation of animal dung (or biomass).

(49) (C). Bt strains have been used to design bio-insecticidal plants, through genetic engineering.

(50) (B)

(51) (B). A biological control being developed for use in the treatment of plant disease is the fungus *Trichoderma*. *Trichoderma* species are free-living fungi that are very common in the root ecosystems. They are effective biocontrol agents of several plant pathogens.

(52) (D). *Nostoc*, *Anabaena* and *Oscillatoria* are cyanobacteria. They fix atmospheric nitrogen and increase the organic matter of soil through their photosynthetic activity. Blue-green algae increase the soil fertility by adding organic matter to the soil.

(53) (D). Fungi are also known to form symbiotic associations with plants (mycorrhiza). Many members of the genus *Glomus* form mycorrhiza. The fungal symbionts in these associations absorb phosphorus from soil and pass it to the plant. Plants having such associations show other benefits also, such as resistance to root-borne pathogens, tolerance to salinity and drought, and an overall increase in plant growth and development.

(54) (C). The most suitable source of biofertiliser is achieved by the use of blue-green algae (cyanobacteria), particularly in rice fields. These organisms grow well in symbiotic association with other plants or as free living individuals on the surface of moist soil or under water logged conditions.

(55) (D). *Pseudomonas* is not a nitrogen fixing bacteria. *Pseudomonas* is a saprophytic bacteria. *Pseudomonas* are used for biodegradation of organic pollutant like petroleum spillage. *Azotobacter* is a free living nitrogen fixing bacteria. *Anabaena* and *Nostoc* are free living nitrogen fixing cyanobacteria.

(56) (C). Biofertilisers are the microorganisms, which enrich the nutrient (nitrogen, phosphorus, etc) quality of the soil. Bacteria like *Rhizobium*, fungi [mycorrhiza (*Glomus*)] and cyanobacteria (*Nostoc* and *Anabaena*) are the three main sources of biofertilisers.

(57) (B). *Rhizobium* are soil bacteria that fix nitrogen after becoming established inside root nodules of legumes (Fabaceae). *Rhizobia* require a plant host; they cannot independently fix nitrogen.

EXERCISE-2

(1) (D)

(2) (D). Actinomycetes are a specific group of bacteria. Many species of Actinomycetes occur in soil and are harmless to animals and higher plants, while some are important pathogens and many others are beneficial sources of antibiotics.

Rhizobium is a symbiotic bacterium that lives in the root nodules of legumes and fixes atmospheric nitrogen into organic compounds.

Azospirillum is a free living bacteria, which absorb free nitrogen from soil, air and convert it into salts of nitrogen like amino acids and enrich soil.

(3) (D)

(4) (C)

(5) (A). *Anabaena* is a genus of filamentous cyanobacteria that exists as plankton. It is known for its nitrogen fixing abilities, and they form symbiotic relationships with certain plants, such as the mosquito fern.

(6) (D)

(7) (C). A distilled beverage is an alcoholic beverage produced by distillation of a mixture produced from alcoholic fermentation. As examples, this does not include beverages such as beer, wine, and cider, as they are fermented but not distilled.

(8) (D) (9) (D)

(10) (D). Paddy fields are a suitable environment for the growth of diazotrophic, oxygenic cyanobacteria, by providing suitable temperature, nutrient and water facilities. In return, cyanobacteria provide a large amount of nitrogen and phosphorus, which are the most required nutrients at the time of rice cultivation.

(11) (C). *Acetobacter aceti* is a Gram negative bacterium that moves using its peritrichous flagella. Louis Pasteur proved it to be the cause of conversion of ethanol to acetic acid in 1864. *Acetobacter aceti* is economically important because it is used in the production of vinegar by converting the ethanol in wine into acetic acid.

(12) (C)

(13) (A). Bt has to be eaten to cause mortality. The Bt toxin dissolve in the high pH insect gut and become active. The toxins then attack the gut cells of the insect, punching holes in the lining. The Bt spores spills out of the gut and germinate in the insect causing death within a couple days.

(14) (B)

(15) (B). Streptokinase, the first thrombolytic drug to reach the market, achieved fame as the iconic clot buster.

(16) (B) (17) (A) (18) (C) (19) (D)

(20) (B) (21) (B) (22) (D) (23) (D)

(24) (B). *Staphylococcus* is a genus of Gram-positive bacteria. Under the microscope, they appear round, and form in grape-like clusters.

(25) (B) (26) (D) (27) (B)

(28) (B). *P. shermani*, releases carbon dioxide when it consumes the lactic acid and forms bubbles. The bubbles don't just disappear, they form little air pockets, resulting in the holes of the Swiss cheese.

(29) (C) (30) (A) (31) (C) (32) (A)

(33) (A). Indicator bacteria are types of bacteria used to detect and estimate the level of fecal contamination of water. *Escherichia coli* (E. coli) and enterococci are used as indicators.

(34) (D)

(35) (D). Cyclosporin-A is an eleven membered cyclic oligopeptide obtained through fermentative activity of fungus *Trichoderma polysporum*. It inhibits activation of T-cells and therefore, prevents rejection reactions in organ transplantation.

(36) (A). The growing microbes consume organic matter and thus reduce the Biochemical Oxygen Demand (BOD).

(37) (C). Yeast used in baking and the alcohol in alcoholic beverages is a type of eukaryotic fungus. Streptokinase is an enzyme obtained from the cultures of some haemolytic bacterium *Streptococcus* and modified genetically to function as clot busters. Lipases are lipid dissolving enzymes that are obtained from *Candida lipolytica* and *Geotrichum candidum*. They are added in detergents for removing oily stains from laundry. Pectinases are obtained commercially from *Byssochlamys fulva*. Along with proteases, they are used in clearing of fruit juices.

(38) (D). All statements are correct. Fresh spores of Bt are mixed with water and sprayed on plants such as brassicas and fruit trees.

(1) (1)

EXERCISE-3

(B). The legume *Sesbania bispinosa*, also known as *Sesbania aculeata* Pers., is a small tree in the genus *Sesbania*. *Trifolium alexandrinum* (Egyptian clover) is an annual clover cultivated mostly in irrigated sub-tropical regions, and used as fodder, mainly for cattle and milk buffalo.

(2) (D) (3) (C) (4) (A) (4) (5) (6) (A)

(7) (A). In green manure quick growing crops cultivated and ploughed into the soil which increase crop yield by 30-50%, e.g., *Sesbania aculiata*, *Crotalaria juncea*, *Vigna sinensis*, *Alhagi comelorum*, etc.

(8) (A). The ladybird and dragonflies are useful to get rid of aphids and mosquitoes, respectively.

(i) A bacteria species namely *Bacillus thuringiensis* (*Bt*) is known to kill a wide range of insects such as butterfly, caterpillars, ant etc., some strains of *Bt* can kill animal and plant parasitic nematodes, protozoans and even cockroaches.

(ii) *Trichoderma* is a free-living saprophytic fungi that most commonly lives on dead organic matter in the soil and rhizosphere.

(iii) The fungus is being developed as an effective biocontrol agent of several plant pathogens.

(iv) *Rhizobium* is a symbiotic bacterium that lives in the root nodules of legumes and fixes atmospheric nitrogen into organic compounds.

(9) (B). Anthrax is a fatal human disease caused by the bacterium *Bacillus anthracis*. This was used as a bioweapon agent in America in September 2001.

(10) (C). Excess fertiliser in the environment, especially nitrogen and phosphorus, can pollute local ground water as well as lakes and streams, resulting in eutrophication.

(11) (B). Harmful insects and pests can be controlled through biological control by the introduction of their natural predators. The major difficulty in this control is that the predator does not always survive when transferred to a new environment.

EXERCISE-4

(1) (C). A good source of citric acid is *Aspergillus niger* (a fungus).

(2) (C). During sewage treatment, biogases includes mixture of gases such as methane, hydrogen sulphide and carbon dioxide.

(3) (B). In anaerobic sludge digesters, bacteria produce a mixture of gases like CH_4 , H_2S and CO_2 .

(4) (A). Methanogens are microorganism that produces methane as a byproduct of its metabolism. These are both archeans and obligate anaerobes.

(5) (C). (A) *Saccharomyces cerevisiae* – Commercial production of ethanol.

(B) *Monascus purpureus* – Production of blood cholesterol lowering agents.

(C) *Trichoderma polysporum* – Production of immuno-suppressive agents.

(D) *Propionibacterium sharmanii* – Ripening of Swiss cheese.

(6) (D). Butyric acid is produced by fermentive activity of *Clostridium butylicum*.

(7) (C). Methanogens are obligate anaerobic ancient and primitive bacteria. They are involved in methanogenesis.

(8) (B). **Microbe** **Product**
Aspergillus niger - Citric acid
Trichoderma polysporum-Cyclosporin-A
Monascus purpureus - Statins
Clostridium butylicum - Butyric acid

(9) (D). *Saccharomyces cerevisiae* is commonly called Brewer's yeast. It causes fermentation of carbohydrates producing ethanol.

(10) (A). Curd is more nourishing than milk. It has enriched presence of vitamins specially Vit-B₁₂.

(11) (B). Statin is obtained from a yeast (Fungi) called *Monascus purpureus*. It acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

(12) (B). Fungi *Trichoderma*, Baculoviruses (NPV) and *Bacillus thuringiensis* are used as biocontrol agents. *Rhizobium*, *Nostoc*, *Azospirillum* and *Oscillatoria* are used as biofertilisers, whereas TMV is a pathogen and aphids are pests that harm crop plants.

(13) (B). Microbes are used in production of several household and industrial products – *Lactobacillus* – Production of curd *Saccharomyces cerevisiae* – Bread making *Aspergillus niger* – Citric acid production *Acetobacter aceti* – Acetic acid.

(14) (A). Fungus *Trichoderma* is a biological control agent being developed for use in the treatment of plant diseases.