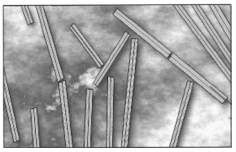
Microbes in Human Welfare

OBJECTIVE TYPE QUESTIONS

Multiple Choice Questions (MCQs)

1. Conversion of milk to curd improves its nutritional value by increasing the amount of
(a) vitamin D (b) vitamin A
(c) vitamin B_{12} (d) vitamin E.

2. Identify the organism shown in the given diagram.



(a) Bacteria
(b) Bacteriophage
(c) TMV
(d) HIV

3. The puffed-up appearance of dough is due to fermentation by bacteria. Identify the gas liberated during the process.
(a) Hydrogen sulphide (b) Methane
(c) Ammonia (d) Carbon dioxide

4. Yeast is used in the production of
(a) bread and beer
(b) cheese and butter
(c) citric acid and lactic acid
(d) lipase and pectinase.

5. Which one of the following is a bacterial biofertiliser?
(a) *Anabaena* (b) *Nostoc*
(c) *Rhizobium* (d) *Oscillatoria*

6. Which one of the following is not used in organic farming?
(a) *Glomus* (b) Earthworm
(c) *Oscillatoria* (d) Snail

7. An organism used as a biofertiliser for raising soyabean crop is
(a) *Azotobacter* (b) *Azospirillum*
(c) *Rhizobium* (d) *Nostoc.*

8. The microbial biocontrol agent for butterfly caterpillar is
(a) *Bacillus thuringiensis*
(b) *Saccharomyces*
(c) *Lactobacillus*
(d) Cyanobacteria

9. Which of the following is correctly matched for the product produced by them?
(a) *Methanobacterium* : Lactic acid
(b) *Penicillium notatum* : Acetic acid
(c) *Saccharomyces cerevisiae* : Ethanol
(d) *Acetobacter aceti* : Antibiotics

10. A nitrogen-fixing microbe associated with *Azolla* in rice fields is
(a) *Spirulina* (b) *Anabaena*
(c) *Frankia* (d) *Tolypothrix*.

11. Match column I with column II and select the correct option using the codes given below.

	Column-I	**Column-II**
A.	Citric acid	(i) *Trichoderma*
B.	Cyclosporin A	(ii) *Clostridium*
C.	Statins	(iii) *Aspergillus*
D.	Butyric acid	(iv) *Monascus*

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

12. Which of the following is wrongly matched in the given table?

	Microbe	**Product**	**Application**
(a)	*Streptococcus*	Streptokinase	Removal of clot from blood vessel
(b)	*Clostridium butylicum*	Lipase	Removal of oil stains
(c)	*Trichoderma polysporum*	Cyclosporin A	Immuno-suppressive drug
(d)	*Monascus purpureus*	Statins	Lowering of blood cholesterol

13. Select the incorrect match.
(a) Citric acid – *Aspergillus niger*
(b) Streptokinase – *Streptococcus*
(c) Butyric acid – *Clostridium acetobutylicum*
(d) Cyclosporin-A – *Monascus purpureus*

14. Which of the following microbes is used for the commercial production of ethanol?
(a) *Clostridium butylicum*
(b) *Trichoderma polysporum*
(c) *Monascus purpureus*
(d) *Saccharomyces cerevisiae*

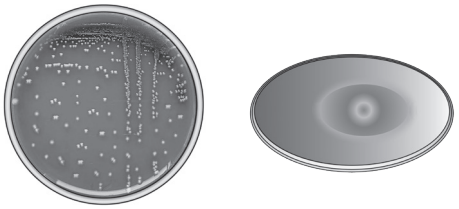
15. Viruses of the genus *Nucleopolyhedrovirus* are employed as
(a) gobar gas producers
(b) biological control agents
(c) anaerobic sludge digesters
(d) atmospheric nitrogen fixing agents.

16. A person admitted to hospital as he had myocardial infarction. A cardiologist injected him 'streptokinase', why?
(a) It stimulates heart beat.
(b) It reduces hypertension.
(c) It acts as clot buster.
(d) It reduces the level of blood cholesterol.

17. Ernst Chain and Howard Florey's contribution was
(a) establishing the potential of penicillin as an effective antibiotic
(b) discovery of streptokinase
(c) production of genetically engineered insulin
(d) discovery of DNA sequence.

18. Select the correct pair of microorganism and the product obtained from it.
(a) *Monascus purpureus* - produces large holes in Swiss cheese.
(b) *Saccharomyces cerevisiae* - used for making wine and beer after distillation.
(c) *Streptococcus* - produces streptokinase which is used to remove clots.
(d) *Aspergillus niger* - produces citric acid and butyric acid.

19. Refer to the given figure and select the correct match.



(A) **(B)**

(a) A-Fungal colony, B-Bacterial colony
(b) A-Viral colony, B-Bacterial colony
(c) A-Bacterial colony, B-Viral colony
(d) A-Bacterial colony, B-Fungal colony

20. 'Roquefort cheese' is ripened by using a
(a) bacterium (b) yeast
(c) cyanobacteria (d) fungus.

21. *Monascus purpureus* is a yeast used commercially in the production of
(a) ethanol
(b) streptokinase for removing clots from the blood vessels
(c) citric acid
(d) blood cholesterol lowering statins.

22. Which among these are produced by distillation of fermented broth?
(i) Whisky (ii) Wine
(iii) Beer (iv) Rum
(v) Brandy
(a) (ii) and (iii) only (b) (i) and (ii) only
(c) (iii) and (v) only (d) (i), (iv) and (v) only

23. Select the correct statement.
(a) *Acetobacter aceti* produces citric acid.
(b) *Saccharomyces cerevisiae* is used as clot buster.
(c) *Penicillium notatum* restrict the growth of *Staphylococci*.
(d) Methanogens are found in aerobic conditions.

24. Match the microbes in column I with their commercial/industrial products in column II and choose the correct answer.

	Column I		**Column II**
A.	*Aspergillus niger*	1.	Ethanol
B.	*Clostridium butylicum*	2.	Statins
C.	*Saccharomyces cerevisiae*	3.	Citric acid
D.	*Trichoderma polysporum*	4.	Butyric acid
E.	*Monascus purpureus*	5.	Cyclosporin A

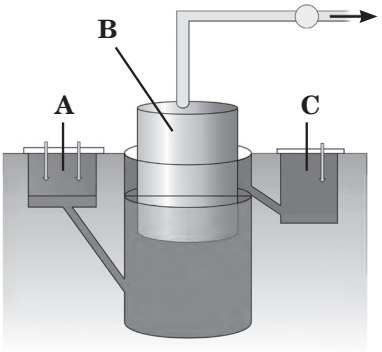
(a) A – 4, B – 5, C – 2, D – 1, E – 3
(b) A – 5, B – 4, C – 1, D – 2, E – 3
(c) A – 3, B – 4, C – 1, D – 5, E – 2
(d) A – 3, B – 4, C – 5, D – 1, E – 2

25. Which of the following in sewage treatment removes suspended solids?
(a) Secondary treatment
(b) Primary treatment
(c) Sludge treatment
(d) Tertiary treatment

26. The primary treatment of sewage water involves
(a) anaerobic bacterial activity
(b) sludge digestion

(c) filtration and sedimentation
(d) aerobic bacterial activity.

27. The given figure represents a typical biogas plant. Select the correct option for A, B and C respectively.



(a) A is the inlet for cattle dung.
(b) C is the outlet for the release of biogas.
(c) B is the chamber which contains leftover slurry.
(d) All of these

28. What gases are produced in anaerobic sludge digesters?
(a) Methane and CO_2 only
(b) Methane, Hydrogen sulphide and CO_2
(c) Methane, Hydrogen sulphide and O_2
(d) Hydrogen sulphide and CO_2

29. The domestic sewage in large cities
(a) has a high BOD as it contains both aerobic and anaerobic bacteria
(b) is processed by aerobic and then anaerobic bacteria in the secondary treatment in Sewage Treatment Plants (STPs)
(c) when treated in STPs does not really require the aeration step as the sewage contains adequate oxygen
(d) has very high amount of suspended solids and dissolved salts.

30. When domestic sewage mixes with river water
(a) small animals like rats will die after drinking river water
(b) the increased microbial activity releases micronutrients such as iron
(c) the increased microbial activity uses up dissolved oxygen
(d) the river water is still suitable for drinking as impurities are only about 0.1%.

31. In biogas plant, the role of acidogenic bacteria is to
(a) convert monomers to organic acids
(b) convert monomers to complex polymers
(c) transform acetic acid to biogas
(d) digest fungi in the sludge.

32. Refer to the given diagram and choose the correct option for it.

(a) Bacteriophage - Tobacco mosaic disease
(b) Adenovirus - Respiratory disease
(c) Viroid - Potato spindle tumour disease
(d) Prion - Alzheimer's disease

33. In gobar gas, the maximum amount is that of
(a) butane (b) methane
(c) propane (d) carbon dioxide.

34. Select the correct statement from the following.
(a) Biogas is produced by the activity of aerobic bacteria on animal waste.
(b) Methanobacterium is an aerobic bacterium found in rumen of cattle.
(c) Biogas, commonly called gobar gas, is pure methane.
(d) Activated sludge-sediment in settlement tanks of sewage treatment plant is a rich source of aerobic bacteria.

35. Which of the following can be used as a biocontrol agent in the treatment of plant disease?
(a) *Lactobacillus* (b) *Trichoderma*
(c) *Chlorella* (d) *Anabaena*

36. Select the correct group of biocontrol agents.
(a) *Nostoc, Azospirillum, Nucleopolyhedrovirus*
(b) *Bacillus thuringiensis,* Tobacco mosaic virus, Aphids
(c) *Trichoderma,* Baculovirus, *Bacillus thuringiensis*
(d) *Oscillatoria, Rhizobium, Trichoderma*

37. A biocontrol agent to be a part of an integrated pest management should be
(a) species-specific and symbiotic
(b) free living and broad spectrum
(c) narrow spectrum and symbiotic
(d) species-specific and inactive on non-target organisms.

38. Match the following organisms with the products they produce.

(A) *Lactobacillus*	(i) Cheese
(B) *Saccharomyces cerevisiae*	(ii) Curd
(C) *Aspergillus niger*	(iii) Citric acid
(D) *Acetobacter aceti*	(iv) Bread
	(v) Acetic acid

Select the correct option.

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

39. Microbe used for biocontrol of pest butterfly caterpillars is

(a) *Saccharomyces cerevisiae*
(b) *Bacillus thuringiensis*
(c) *Streptococcus sp.*
(d) *Trichoderma sp.*

40. Select the mismatch.

(a) *Rhodospirillum*	–	Mycorrhiza
(b) *Anabaena*	–	Nitrogen fixer
(c) *Rhizobium*	–	*Alfalfa*
(d) *Frankia*	–	*Alnus*

Case Based MCQs

Case I : Read the following passage and answer the questions from 41 to 45 given below.

Yeast and certain bacteria play a key role fermentation to breakdown carbohydrates into ethanol and carbon dioxide which then further used to prepare acetic acid with the help of bacterium *Acctobacter aceti*. Alcoholic fermentation in anaerobic process, but the conversion of alcohol to acetic acid is aerobic one. This process can be represented by following equation :

$$C_6H_{12}O_6 \xrightarrow[\text{Complex}]{\text{Zymase}} \underset{\text{Ethyl alcohol}}{2C_2H_5OH} + 2CO_2$$

$$C_2H_5OH + O_2 \longrightarrow \underset{\text{Acetic acid}}{CH_3COOH} + H_2O$$

41. The rate of alcohol production is measured on the basis of

(a) amount of sugar present in the medium
(b) amount of CO_2 produced per unit time
(c) amount of yeast added in the medium
(d) all of these.

42. A number of chemicals are produced at the time of alcoholic fermentation with the change of nutrient media, pH and aeration. Select such by-product from the following.

(a) Butanol (b) Succinic acid
(c) Acetaldehyde (d) All of these

43. During alcoholic fermentation of cereals and potato, the crushed food mixed with hot water for obtaining malt is called

(a) juice (b) mash
(c) wort (d) none of these.

44. Distilled alcohol with 95% ethanol content is called

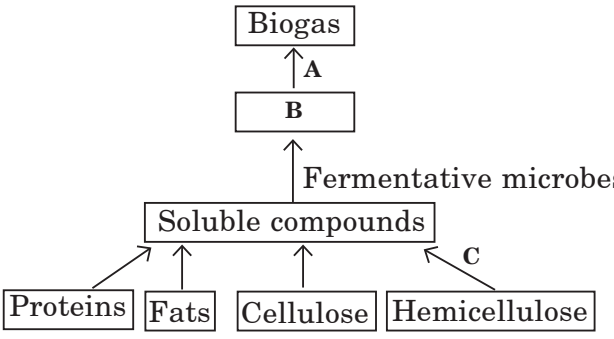
(a) absolute alcohol (b) rectified spirit
(c) gin (d) brandy.

45. _____ is used in the preparation of vinegar.

(a) toddy (b) acetic acid
(c) butter (d) both (a) and (b).

Case II : Read the following passage and answer the questions from 46 to 50 given below.

Villagers in a place near Chambur started planning to make power supply for agricultural purposes from cow dung. They have started a biogas plant for the purpose. Study the flow chart for biogas production given below and answer the following questions.



46. Biogas is composed of majorly
(a) methane, CO_2 and O_2
(b) CO_2, H_2S and H_2O
(c) methane, CO_2 and H_2S
(d) H_2S, H and O_2.

47. In the given flow chart, 'A' denotes
(a) aerobic bacteria
(b) methanogenic bacteria
(c) cellulose degrading bacteria
(d) yeast and protozoa.

48. What is represented by 'B' in the flow chart?
(a) Carbohydrates
(b) Protein polymers
(c) Organic acids
(d) Fat globules

49. 'C' in the given flow chart causes
(a) aerobic breakdown of complex organic compounds
(b) anaerobic digestion of complex organic compounds
(c) fermentation of organic compounds
(d) fermentation of monomers.

50. If 'A' is not added in the procedure
(a) methane will not be formed
(b) CO_2 will not be formed
(c) organic compounds will not be converted to H_2S
(d) O_2 will not be formed.

Assertion & Reasoning Based MCQs

For question numbers 51-60, two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.

51. Assertion : *Azotobacter* fixes nitrogen in symbiotic form.
Reason : *Rhizobium* form root nodules in the roots of leguminous plants.

52. Assertion : *Azolla* is used as a biofertiliser in rice fields.
Reason : *Azolla* shows the presence of N_2 - fixing bacteria in its leaf cavities.

53. Assertion : Whisky develops colour during the aging process.
Reason : Vodka is colourless.

54. Assertion : An organism which acts as herbicide is called bioherbicide.
Reason : *Phytophthora palmivora* is a mycoherbicide.

55. Assertion : *Saccharomyces ellipsoidens* is Brewer's yeast.
Reason : Brewer's yeast produces beer not wine.

56. Assertion : Curdling is required in the manufacture of cheese.
Reason : Lactic acid bacteria and rennet is used for the purpose.

57. Assertion : Acetic acid is prepared by acetic acid bacteria.
Reason : Alcoholic fermentation and the conversion of alcohol to acetic acid are aerobic processes.

58. Assertion : *Aspergillus niger* produces lactic acid.
Reason : *Aspergillus niger* carry out fermentation.

59. Assertion : The alcoholic content of fortified wines are high.
Reason : The fermentation is stopped before all the sugars are being converted.

60. Assertion : Champagne gives off bubbles.
Reason : Alcoholic content is 12 - 16% in champagne.

SUBJECTIVE TYPE QUESTIONS

Very Short Answer Type Questions (VSA)

1. What is the economic value of *Spirulina*?

2. BOD of two samples of water A and B were 120 mg/L and 400 mg/L respectively. Which sample is more polluted?

3. Name the enzyme produced by *Streptococcus* bacterium. Explain its importance in medical sciences.

4. Name the metabolic pathway associated with the rising of dough in making bread. What makes the dough rise?

5. Write the commercial use of lipases.

6. Name the nutrient that gets enhanced while curdling of milk by *Lactobacillus*.

7. Name the group of organisms and the substrate they act on to produce biogas.

8. List two advantages that a mycorrhizal association provides the plant.

9. Write the biochemical reaction of yeast fermentation of molasses for alcohol production.

10. Which of the following is a free living bacteria that can fix nitrogen in the soil?

Spirulina, Azospirillum, Sonalika

Short Answer Type Questions (SA-I)

11. Name the bacterium responsible for the large holes seen in "Swiss Cheese". What are these holes due to?

12. Why are some molecules called bioactive molecules? Give two examples of such molecules.

13. What makes the *Nucleopolyhedrovirus* a desirable biological control agent?

14. Name the blank spaces a, b, c and d in the table given below.

Type of microbe	Name	Commercial product
Bacterium	a	Lactic acid
Fungus	b	Cyclosporin A
c	*Monascus purpureus*	Statin
Fungus	*Penicillium notatum*	d

15. How has the fungus, *Trichoderma polysporum* proved to be very essential to organ-transplant patients?

16. How does the application of the fungal genus, *Glomus*, to the agricultural farm increase the farm output?

17. Name the source of streptokinase. How does this bioreactor molecule function in our body?

18. Your advice is sought to improve the nitrogen content of the soil to be used for cultivation of a non-leguminous terrestrial crop.

(a) Recommend two microbes that can enrich the soil with nitrogen.

(b) Why do leguminous crops not require such enrichment of the soil?

19. State one reason for adding blue-green algae to the agricultural soil.

20. Name the organism that fixes nitrogen in symbiotic association with a water fern. Where does it live in such plant?

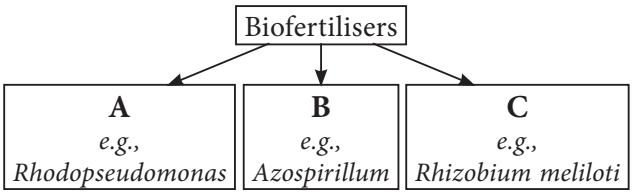
Short Answer Type Questions (SA-II)

21. Why biogas is more suitable and advantageous in rural areas?

22. (a) Why are the fruit juices bought from market clearer as compared to those made at home?

(b) Name the bioactive molecules produced by *Trichoderma polysporum* and *Monascus purpureus*.

23. Study the given flow chart and answer the following questions.



(a) Identify the labelled parts A, B and C in the given flow chart.

(b) Briefly explain biofertiliser C.

(c) How is biofertiliser A different from B?

24. During the production of curd, a small amount of curd is added as a starter to the fresh milk at a suitable temperature. Explain the changes the milk undergoes when it sets into curd.

25. Distinguish between the roles of flocs and anaerobic sludge digesters in sewage treatments.

26. Describe the functions of anaerobic sludge digester in a sewage treatment plant.

27. (a) Give the metabolic pathway involved in the puffing up of *idli* dough.

(b) Name the two different categories of microbes naturally occurring in sewage water. Explain their role in cleaning sewage water into usable water.

28. Name the genus to which baculoviruses belong. Describe their role in the integrated pest management programmes.

29. Choose any three microbes from the following which are suited for organic farming which is in great demand these days for various reasons. Mention one application of each one chosen.
Mycorrhiza; *Monascus*; *Anabaena*; *Rhizobium*; *Methanobacterium*; *Trichoderma*.

30. Explain the role of baculoviruses as biological control agents. Mention their importance in organic farming.

31. (a) What are the properties of an antibiotic?

(b) Explain the scientific reason for growing *Azolla pinnata* in the rice field.

32. (a) Organic farmers prefer biological control of diseases and pests to the use of chemicals for the same purpose. Justify.

(b) Give an example of a bacterium, a fungus and an insect that are used as biocontrol agents.

33. Define the term biofertilizers? How does each of the following serve as a biofertilizer?

(i) *Rhizobium** **(ii)** Ectomycorrhiza

Long Answer Type Questions (LA)

34. Name the site of nitrogen fixation in legumes. List and describe the biochemical components at this site.

35. What are biofertilisers? Describe their role in agriculture. Why are they preferred over chemical fertilisers?

36. (a) Explain the process of sewage water treatment before it can be discharged into natural water bodies.

(b) Why is this treatment essential?

37. Prior to sowing rice, a legume crop was cultivated and ploughed back in the field, why? Explain.

ANSWERS

OBJECTIVE TYPE QUESTIONS

1. (c) : *Lactobacillus* bacteria convert milk into curd. They produce acids that coagulate and partially digest the milk proteins. A small amount of curd added to the fresh milk as inoculum or starter contains millions of *Lactobacillus* which at suitable temperature multiply, thereby converting milk to curd this improves its nutritional value by increasing vitamin B_{12} content and a number of organic acids.

2. (c) : Tobacco mosaic virus is a rod like virus with a length of 300 nm and diameter of 18 mm. TMV capsids are composed of 2130 identical protein subunits which assemble around the viral ssRNA to form helical structure with a hollow central cavity of 4 mm diameter.

3. (d) : Fermentation of glucose in dough mainly forms ethyl alcohol and carbon dioxide which causes leavening of dough.

4. (a) : The dough which is used for making bread, is fermented by baker's yeast (*Saccharomyces cerevisiae*).

Besides bread, yeast fermentation is involved in the production of beer, wine, vinegar, etc. Several traditional drinks and food items are also made by fermentation of yeast.

5. (c)

6. (d) : Organic farming is a method of farming system which primarily aimed to keep the soil alive and in good health by use of organic wastes and other biological material along with beneficial microbes (biofertilisers) to release nutrients to crops for increased sustainable production in an ecofriendly, pollution free environment. Basic components of organic farming are green manures, farm yard manure, vermicompost, crop rotation, biopesticides and biofertilisers. *Glomus* being a mycorrhizal component, earthworm being a vermicompost and *Oscillatoria* being a nitrogen fixing blue green algae can be used in organic farming. Snail cannot be a component of organic farming.

7. (c) : *Rhizobium* is used as a biofertiliser for raising crop. *Rhizobium japonicum* forms symbiotic association in the roots of the leguminous plant, soyabean.

8. (a) : Spores of bacterium *Bacillus thuringiensis* produce the insecticidal cry protein. Therefore, spores of this bacterium kill larvae of insects which eat them.

9. (c) : *Methanobacterium* is useful in the production of biogas. *Penicillium notatum* is used to produce penicillin, an antibiotic. *Acetobacter aceti* is used to obtain acetic acid.

10. (b) : *Azolla* plays a very important role in rice production. *Azolla* and its nitrogen-fixing partner, *Anabaena*, have been used as green manure to fertilise rice paddies and increase production. With the help of *Azolla*, rice can be grown year after year, several crops a year, with little or no decline in productivity; hence no rotation of crops is necessary.

11. (b)

12. (b) : *Clostridium butylicum* helps in the production of butyric acid. *Candida lipolytica* and *Geotrichum candidum* help in production of lipases that are added in detergents for removing oily stains from laundry.

13. (d) : Cyclosporin is used as immunosuppressant. This drug is derived from a fungus, *Trichoderma polysporum* and is used to prevent rejection of kidney, heart and liver transplants. Cyclosporin inhibits the activity of helper T-cells that acts against foreign bodies.

14. (b) : Yeast (*Saccharomyces cerevisiae*) is used for the commercial production of ethanol.

15. (b) : Baculoviruses (mostly of genus *Nucleopolyhedrovirus* NPV) are useful in controlling many insects and other arthropods. They are species specific narrow spectrum bioinsecticides. There is no side effect on plants, mammals, birds, fish and nontarget insects. Beneficial insects are conserved. Baculoviruses are, therefore, an important component of integrated pest management (IPM) programme and are dealing with ecological sensitive areas.

16. (c) : Enzyme streptokinase is produced by the bacterium *Streptococcus* and modified by genetic engineering to be used as a clot buster for removing clots from blood vessels of patients who have undergone mycocardial infarction leading to heart attack.

17. (a) : Penicillin was the first antibiotic to be discovered by Alexander Fleming (1928). He found that fungus *Penicillium notatum* or its extract could inhibit the growth of bacterium *Staphylococcus aureus*. However, its full potential as an effective antibiotic was established much later by Ernst Chain and Howard Florey. This antibiotic was extensively used to treat American soldiers wounded in the World War II. Fleming, Chain and Florey were awarded the Nobel prize in 1945, for this discovery.

18. (c) : Statins produced by the yeast *Monascus purpureus* is used as blood-cholesterol lowering agents. *Saccharomyces cerevisiae* is used for making bread and ethanol. *Aspergillus niger* (a fungus) produces citric acid only.

19. (d) : The given figures (A) and (B) respectively shows bacteria and fungal colonies growing in petri dishes.

20. (d) : Adding lactic acid bacteria (LAB) to milk, results in formation of curd, because of coagulation of milk proteins. This curd is further processed to form cheese. Cheese can be classified on the basis of their texture or hardness and ripening. Roquefort cheese is a semisoft cheese. In this cheese, spores of fungus *Penicillium roqueforti* are added to the curd before final stages of cheese production.

21. (d)

22. (d) : Hard liquors such as gin, whisky, sake, arrak, brandy or rum are obtained by distillation of fermented broth.

23. (c) : *Acetobacter aceti* produces acetic acid. *Saccharomyces cerevisiae* is used for commercial production of ethanol. Bacteria which produce methane are collectively called methanogens, and one such common bacterium is *Methanobacterium*. These bacteria are commonly found in the anaerobic sludge during sewage treatment.

24. (c)

25. (b) : Primary or physical treatment is the process of removal of small and large, floating and suspended solids from sewage through two processes of filtration and sedimentation.

26. (c)

27. (a) : The given figure is of a biogas plant, in which A is Inlet for cattle dung and water; B is Gas holder and C is Outlet for leftover slurry.

28. (b) : The type of gases produced by microbial activity depend upon the microbes and the organic substrates they utilise. Certain bacteria called methanogens grow anaerobically on cellulosic material and produce large amount of methane along with carbon dioxide. These bacteria are commonly found in the anaerobic sludge during sewage treatment.

Other anaerobic bacteria, involved in the process of anaerobic digestion produce other gases like ammonia and hydrogen sulphide.

29. (b)

30. (c) : When sewage mixes with water body, micro-organisms present in it biodegrade organic matter of sewage using oxygen. This results into a sharp decline in dissolved oxygen which may cause mortality of aquatic creatures.

31. (a)

32. (b) : The picture shown in the question is of adenovirus. It most commonly causes respiratory illness which ranges from common cold to pneumonia, croup and bronchitis.

33. (b) **34. (d)**

35. (b) : *Trichoderma* species are free-living fungi that are very common in the root ecosystems. They are effective biocontrol agents of several plant pathogens.

36. (c) **37. (d)**

38. (c) **39. (b)**

40. (a) : *Rhodospirillum* is a free-living nitrogen fixing bacteria. Mycorrhiza is the symbiotic association between fungi and roots of higher plants. The most common fungal partners of mycorrhiza are *Glomus* species.

41. (b) : The fermentation rate of the yeast can be calculated by measuring the volume of CO_2 and dividing it by the amount of time it took for that volume to form.

42. (d)

43. (b) : The crushed food mixed with hot water for obtaining malt is called mash. The sweetened nutrient medium prior to fermentation is called wort. Wort is added into the bioreactor tank, sterilised and then inoculated with yeast.

44. (b) : Alcoholic content in gin is 40%, brandy in 60-70%. These are hard liquors. Rectified spirit contains 95% alcohol and absolute alcohol is 100% alcohol. Rectified spirit and absolute alcohol are extensively used in laboratory works.

45. (d)

46. (c) : Biogas is composed of methane (50-70%), carbon dioxide (30-40%) with traces of nitrogen, hydrogen sulphide and hydrogen.

47. (b)

48. (c) : In the second stage of biogas production, the simple soluble compounds or monomers are acted upon by fermentation causing microbes and converted into organic acids especially acetic acid.

49. (b) **50. (a)**

51. (d) : *Azotobacter* is a non-symbiotic nitrogen fixing bacteria *i.e.*, it lives freely in the soil and perform nitrogen fixation. It is saprotrophic living on organic remains. Root nodules are formed by *Rhizobium*, a symbiotic nitrogen fixing bacteria.

52. (a) : *Azolla* can co-exist with rice plants because it does not interfere with their growth. In some South East Asian countries, especially China, the rice fields are regularly provided with *Azolla*. The fern is stocked in a corner of rice field and provided with manure, ash and straw before transplantation. When the field is flooded at the time of transplantation, the fern spreads rapidly and covers the space in between the rice plants. *Anabaena*, a blue green algae resides in the leaf cavities of the fern. It fixes nitrogen. A part of the fixed nitrogen is excreted in the cavities and becomes available to the fern. The decaying fern plants release the same for utilisation by the rice plants.

53. (b) : The whiskies are aged in charred oak containers. At first the whisky is colourless, the colour develops during the aging process. The vodka is not aged and bottled immediately after distillation and therefore it remains colourless.

54. (b) : An organism which controls or destroys unwanted plant growth without harming the useful plant is called bioherbicide. The first bioherbicide happened to be mycoherbicide (fungal herbicide). It was elaborated in 1981. This herbicide is *Phytophthora palmivora*. The fungus does not allow the Milkweed vine to grow in citrus orchards.

55. (d)

56. (b) : The manufacture of cheese requires two main steps curdling and the ripening. Curdling the milk proteins forms a solid material from which the liquid is drained away. The curdling process may be exclusively microbiological, since acid production of lactic acid bacteria is sufficient to coagulate milk proteins. However, an enzyme known as rennin (extracted from the stomachs of calves or rennet) which curdles milk is often used for this purpose.

57. (c) : Acetic acid is prepared from fermented alcohols with the help of acetic acid bacteria, *Acetobacter aceti*. Alcoholic fermentation is anaerobic process but the conversion of alcohol to acetic acid is aerobic one.

58. (d) : Citric acid is obtained through the fermentation carried out by *Aspergillus niger* and *Mucor* species on sugary syrups. Lactic acid was the first organic acid to be produced from the microbial fermentation. Lactic acid fermentation is carried out by both bacteria (*e.g. Streptococcus lactis*, *Lactobacillus* species and fungi (*e.g. Rhizopus*).

59. (b) : In fortified wines, the fermentation is stopped before all the sugar is being converted and at least 1 percent is still present. The still wines have a higher alcoholic content due to the addition of wine, brandy or alcohol.

60. (b) : Champagne wines are bottled before fermentation is complete. These wines give off bubbles of gas. Alcohol content is 12 - 16%.

SUBJECTIVE TYPE QUESTIONS

1. *Spirulina* is single cell protein (SCP), which is rich in high quality protein and is used for consumption as human food and animal feed.

2. Water body having high BOD is more polluted as compared to water body having low BOD. Hence water sample having BOD 400 mg/L is more polluted as compared to water sample having BOD 120 mg/L.

3. Streptokinase is produced by bacterium *Streptococcus*. Streptokinase is modified by genetic engineering which is further used as a 'clot bluster' for removing clots from the blood vessels of the patients who have undergone myocardial infarction leading to heart attack.

4. When *Saccharomyces cerevisiae* (baker's yeast) is added to dough it causes its fermentation and releases CO_2 gas which is responsible for puffed up appearance of dough.

5. Lipases are used in detergents formulations and are helpful in removing oily stains from the laundry.

6. The curdling of milk by *Lactobacillus* changed milk into curd and its nutritional quality is enhanced due to increase in vitamin B_{12} content.

7. Methanogenic bacteria or methanogens are the group of anaerobic microbes which digest organic mass as well as aerobic microbes of the sludge to produce a mixture of gases containing methane, H_2S and CO_2 called biogas.

8. Mycorrhiza perform following functions for the plant :

(i) Absorption of water and minerals like phosphorus from the soil and passing it to the plants.

(ii) Solubilisation of organic matter of the soil humus and their transfer to roots.

9. The biochemical reaction for anaerobic fermentation is

$$C_6H_{12}O_6 \xrightarrow[\text{Yeast fermentation}]{} 2C_2H_5OH + 2CO_2$$

10. *Azospirillum* is a free living nitrogen fixing bacteria.

11. Bacterium responsible for large holes in Swiss cheese is *Propionibacterium shermanii*. Large holes in Swiss cheese are due to CO_2 gas produced by these bacteria.

12. Bioactive compounds are those compounds that have an effect on living organisms tissues or cells. Bioactive compounds are found in both plant and animal products or can be synthetically produced. Two examples of bioactive compounds are cyclosporin A and statins.

13. *Nucleopolyhedrovirus* a genus of baculoviruses are useful in controlling many insects and other arthropods. They are species specific narrow spectrum bioinsecticides with no side effects on plants, mammals, birds, fish and non-target insects. Therefore, they serve as an important component of integrated pest management programme in dealing with ecological sensitive areas. These properties are useful in organic farming.

14. a = *Lactobacillus bulgaricus*
b = *Trichoderma polysporum*
c = Yeast (Fungus)
d = Penicillin

15. *Trichoderma polysporum* produces a bioactive molecule known as cyclosporin–A which has antifungal, anti-inflammatory and immunosuppressive properties. It inhibits activation of T-cells and therefore, prevents rejection reactions in organ transplantation.

16. Many members of the genus *Glomus* form symbiotic associations with plants to form mycorrhiza. *Glomus* helps to absorb phosphorus from soil and passes 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. Therefore, *Glomus* increases the farm yield.

17. *Refer to answer 3*.

18. (a) *Azotobacter* and *Azospirillum*.

(b) Leguminous crops have symbiotic nitrogen fixing bacteria such as *Rhizobium* that live in the root nodules of these plants. These bacteria obtain food and shelter from the plant and in return they trap nitrogen directly from the atmosphere which they provide to the plant.

19. A number of free living and symbiotic blue green algae or cyanobacteria have the property of nitrogen fixation and are photosynthetic. Therefore, they add organic matter as well as extra nitrogen to the soil. Hence, blue green algae serve as biofertilisers and are added to agricultural fields such as cotton, maize, jowar, rice, etc.

20. *Anabaena azollae* (blue green alga) fixes nitrogen in symbiotic association with a water fern. It resides in the leaf cavities of the fern.

21. Biogas is more suitable and advantageous in rural areas as :

(i) It provides both energy and manure.

(ii) Biogas has wider applications than the direct burning of organic wastes.

(iii) The energy value of biogas is lower than that of organic matter but due to more efficient handling, the net energy output is roughly equal to the output in direct burning of organic wastes.

(iv) It minimises the chances of spread of faecal pathogens.

(v) The fertiliser value of the manure produced in biogas plants is similar to that of manure formed directly from organic wastes.

(vi) Biogas use does not add to pollution.

22. (a) The fruit juices sold in market or bottled juices are treated with pectinases and proteases which makes them clearer than those made at home.

(b) Cyclosporin A is obtained from fungus *Trichoderma polysporum* whereas statin is obtained from yeast *Monascus purpureus*.

Cyclosporin A has immunosuppressive properties. It inhibits activation of T cells and therefore prevents rejection of transplants. Statin inhibits cholesterol synthesis and is therefore used in lowering blood cholesterol.

23. (a) In the given flow chart A represents free living nitrogen fixing bacteria, B represents loose association of nitrogen fixing bacteria and C represents symbiotic nitrogen fixing bacteria.

(b) Symbiotic nitrogen fixing bacteria form a mutually beneficial association with the plants. The bacteria obtain food and shelter from plants. In return, they give a part of their fixed nitrogen to the plants. The most important symbiotic nitrogen fixing bacteria is *Rhizobium*. It forms nodules on the roots of legume plants. There are about a dozen species of *Rhizobium* which form association with different legume roots, *e.g., R. leguminosarum, R. lupini, R. trifolii, R. meliloti, R. phaseoli*. These bacteria, live freely in the soil but cannot fix nitrogen except for a strain. They develop the ability to fix nitrogen only when they are present inside the root nodules. In the nodule cells, bacteria (bacteroids) lie in groups surrounded by membrane of the host which is lined by a pink-red pigment called leghaemoglobin.

(c) Differences between free living (A) and loosely associating (B) nitrogen fixing bacteria are:

	Free living nitrogen fixing bacteria	Loose association of nitrogen fixing bacteria
(i)	They live freely in the soil and perform nitrogen fixation.	They live around the roots of higher plants without developing any intimate connection.
(ii)	They are not dependent on plant exudates for their food requirement.	The bacteria use plant exudates as part of their food requirement.
(iii)	Some examples of bacteria are - *Rhodospirillum*, *Chromatium*, *Beijerinckia*, etc.	Species of *Azospirillum* mainly shows this kind of nitrogen fixation.

24. The starter or inoculum used in preparation of milk products actually contains millions of lactic acid bacteria. Curd is prepared by inoculating cream and skimmed milk with *Lactobacillus acidophilus* at a temperature of about 40° C or less. *Lactobacillus* converts lactose sugar of milk into lactic acid which causes coagulation and partial digestion of milk protein casein and milk gets changed into curd, which also improves its nutritional quality by increasing vitamin B_{12} content.

25. Aerobic bacteria and fungi constitute 'flocs'. Flocs are masses of aerobic bacteria held together by slime and fungal filaments to form mesh like structures. These microbes digest a lot of organic matter converting it into microbial biomass and releasing a lot of minerals. This reduces biochemical oxygen demand or BOD.

In anaerobic sludge digesters, aerobic microbes present in the sludge get killed. Anaerobic microbes digest the organic mass as well as aerobic microbes of the sludge. During this digestion, bacteria produce a mixture of gases such as methane, hydrogen sulphide and carbon dioxide. These gases form biogas which can be used as source of energy as it is inflammable. The spent sludge of anaerobic sludge digester can be used as manure or part of compost.

26. In secondary sewage treatment, the sediment of settling tank is called activated sludge. A part of it is used as inoculum in aeration tank. The remaining is passed into a large tank called anaerobic sludge digester. It is designed for continuous operation. The aerobic microbes present in the sludge get killed. Anaerobic microbes digest the organic mass as well as aerobic microbes of the sludge. They are of two types, nonmethanogenic and methanogenic. Methanogenic bacteria produce a mixture of gases containing methane, H_2S and CO_2. The mixture called biogas is inflammable and is a source of energy. The spent sludge can be used as manure or part of compost.

27. (a) The metabolic pathway involved in the puffing up of *idli* dough is fermentation in which incomplete oxidation of glucose is achieved under anaerobic conditions by sets of reactions that produces CO_2. Carbon dioxide produced during fermentation causes puffing up of *idli* dough.

(b) Aerobic heterotrophs like bacteria and fungi occur in sewage water. They are natural decomposers and digest a lot of organic matter present in the polluted water thereby releasing minerals and reducing organic waste. Hence, they play an important role in cleaning water and making it fit for various domestic uses.

28. *Refer to answer 13.*

29. Among the given microbes, the ones which are in great demand for organic farming are: Mycorrhiza, *Anabaena* and *Rhizobium*. Mycorrhiza is a mutually beneficial or symbiotic association of a fungus with the roots of a higher plant. Mycorrhizal roots show a sparse or dense wooly growth of fungal hyphae on their surface. Plants having mycorrhizal associations show resistance to root-borne pathogens. *Anabaena* is free living and symbiotic nitrogen fixing cyanobacteria. Cyanobacteria are photosynthetic and have the property of nitrogen fixation. They add organic matter as well as extra nitrogen to the soil. Cyanobacteria are an extremely low cost biofertilisers. *Rhizobium* is symbiotic nitrogen fixing bacteria. They form a mutually beneficial association with the plants. The bacteria obtain food and shelter from plants. In return, they give a part of their fixed

nitrogen to the plants, thus enhancing the availability of nutrient to crops. It forms nodules on the roots of legume plants. They develop the ability to fix nitrogen only when they are present inside the root nodules.

30. Baculoviruses (a group of viruses) are known to infect the larval stages of many harmful insects such as ants, wasps, gnats and beetles. These biological weapons are not only effective as potential biological control of these insects, but are also harmless to non-target organisms (plants, mammals, birds, fish, or even non-target insects). Majority of baculoviruses belong to the genus *Nucleopolyhedrovirus* and are used as biopesticides during organic farming. Organic farming is a technique of raising crops through the use of manure, fertilizers and pesticides of biological origin.

31. (a) Antibiotics are chemical substances produced by some microbes which in small concentration can kill or retard the growth of harmful microbes without adversely affecting the host. Broad spectrum antibiotic can kill or destroy a number of pathogens that belong to different groups with different structures and wall compositions. Specific antibiotics are effective only against one type of pathogen. Good antibiotics should be harmless to host with no side effects. They should be harmless to beneficial microorganism of alimentary canal and should be effective against all strains of pathogen. They should also be quick in action.

(b) *Azolla pinnata* supplies nitrogen, increases physicochemical properties of soils such as soil structure, texture, water holding capacity, cation exchange capacity and pH by providing several nutrients and sufficient organic matter. So, *Azolla pinnata* grows in rice field to increase productivity.

32. (a) Chemical pesticides used in agricultural fields are toxic and they kill even useful organisms along with harmful ones, harm human beings and animals, pollute soil, water and crop plants. It is estimated that despite the use of chemical pesticides 30% of the agricultural produce is lost to pathogens and pests because these continue to develop resistance against various pesticides. Now, organic farmers prefer biological control of diseases and pests to the use of chemicals. Biopesticides are the biological agents that control the growth of weeds, insects and pathogens in an agricultural field. They have targeted actions and are harmless to the crop plants, other beneficial field animals and humans. In organic farming, pests and pathogens are not eradicated but kept at manageable levels by a system of checks and balances as operating in ecosystem. An organic farmer holds the view that eradicating pests is undesirable because without them the beneficial predatory and parasitic organisms which depend upon them for food would also be annihilated.

(b) Bacterium as a biocontrol agent : *Bacillus thuringiensis* is effective against the cabbage looper.

Fungi as a biocontrol agent : *Trichoderma* found in root ecosystem exerts biocontrol over several plant pathogens.

Insect as a biocontrol agent : Lady bird beetle and dragonflies feeds on aphids and prey upon mosquitoes, respectively.

33. Biofertilizers are microorganisms which bring about nutrient enrichment of soil by enhancing the availability of nutrients like nitrogen (N) and phosphorus (P) to crops. The microorganisms which act as biofertilizers are bacteria, cyanobacteria (blue green algae) and mycorrhizal fungi.

(i) *Rhizobium* is one of the most important symbiotic nitrogen fixing bacteria. It forms nodules on the roots of legume plants. They develop the ability to fix nitrogen only when they are present inside the root nodules. In the nodule cells, bacteria (bacteroids) lie in groups surrounded by membrane of the host which is lined by a pink-red pigment called leghaemoglobin. Leghaemoglobin in root nodules rapidly combines with oxygen and protects the enzyme nitrogenase by any inhibitory effect of oxygen.

(ii) In ectotrophic mycorrhiza, the fungal mycelium completely encloses the feeder rootlets forming sheath or mantle. The mantle of fungal hyphae increases the absorptive surface of roots and hence serve better intake of nutrients such as nitrogen, phosphorus, calcium and potassium from the surrounding soil. The major functions which ectomycorrhiza perform are (a) absorption of water, (b) solubilisation of complex organic molecules into simple inorganic nutrients, their absorption and transfer to the roots, and (c) protection of plants from attack of disease-inciting pathogens by secreting antimicrobial substances. Ectomycorrhizae are known to occur in *Pinus*, *Quercus*, *Betula*, *Eucalyptus*, peach, etc.

34. Symbiotic nitrogen fixation is carried out by bacteria frequently found in the root nodules of leguminous plants. The different components and their role in symbiotic nitrogen fixation are as follows:-

(i) *Rhizobium* : They are symbiotic nitrogen fixing bacteria commonly present in root nodules of leguminous plants and carry out conversion of atmospheric nitrogen into nitrogenous salts to make it available for absorption by plants.

(ii) Lectin : Lectins are the key proteins involved in the *Rhizobium*-legume symbiotic association. Bauer (1981) proposed that these lectins interact selectively with microbial cell carbohydrates (or glycoproteins) found in the capsule of bacteria and serve as determinants of recognition or host specificity.

(iii) Tryptophan : Leguminous plants release tryptophan in the soil which is absorbed by *Rhizobium* and is metabolised to produce IAA.

(iv) Root hair curling factor : The rhizobia produce another characteristic substance called root hair curling factor that causes deformation and twisting of root hairs.

(v) Leghaemoglobin : The nodule contains a pink coloured pigment leghaemoglobin which is like true haemoglobin combines with oxygen and CO_2 gets readily oxidised into brown form with a trivalent iron.

(vi) Nitrogenase : Process of nitrogen fixation, involves reduction of atmospheric nitrogen to ammonia (NH_3) by the enzyme nitrogenase. Nitrogenase is made up of two protein components, one containing iron and molybdenum, known as Mo-Fe protein or molybdo-ferredoxin (component I) and the other containing only iron called Fe-protein or azoferredoxin. Nitrogenase is extremely sensitive to oxygen. The enzyme remains active under anaerobic conditions. The leghaemoglobin binds with oxygen and protect nitrogenase from O_2 inactivation. At the same time it is able to make O_2 available to bacteroids for ATP production, required for nitrogen fixation.

35. Biofertilisers are microorganisms which bring about nutrient enrichment of soil by enhancing the availability of nutrients like nitrogen (N) and phosphorus (P) to crops. Biofertilisers includes–nitrogen fixing bacteria, nitrogen fixing cyanobacteria and mycorrhiza. *Azotobacter* occurring in fields of cotton, maize, jowar and rice, not only increases yield but also saves nitrogen fertiliser upto 10–25 kg/ha.

A number of free living cyanobacteria or blue-green algae have the property of nitrogen fixation, e.g., *Anabaena, Nostoc*, *Oscillatoria*, *Tolypothrix*. Cyanobacteria are extremely low cost biofertilizers.

The most important of the symbiotic nitrogen fixing bacteria is *Rhizobium*. It forms nodules on the roots of legume plants. There are about a dozen species of *Rhizobium* which form association with different legume roots, *e.g., R. leguminosarum*, *R. lupini*, *R. trifolii*, *R. meliloti*, *R. phaseoli*.

Nitrogen fixing cyanobacteria (blue–green algae) form symbiotic association with several plants, *e.g.*, cycad roots, lichens, liverworts, *Azolla* (fern). *Azolla–Anabaena* association is of great importance to agriculture. *Azolla pinnata* is a free floating fresh water fern which multiplies rapidly, doubling every 5–7 days. The fern can coexist with rice plants because it does not interfere with their growth. In some South-East Asian countries, especially China, the rice fields are regularly provided with *Azolla*.

Chemical fertilisers cause pollution of water bodies as well as ground water, besides getting stored in crop plants. Therefore, farmers are pressing for switch over to organic farming which includes the use of manures biofertilisers, biopesticides. Biofertilisers are microorganisms which bring about nutrient enrichment of soil by enhancing the availability of nutrients to crops. The microorganisms which act as biofertilisers are bacteria, cyanobacteria (blue green algae) and mycorrhizal fungi. Bacteria and cyanobacteria have the property of nitrogen fixation while mycorrhizal fungi preferentially withdraw minerals from organic matter for the plant with which they are associated. Phosphate is also solubilised by some bacteria and by some fungi that form association with plant roots.

36. (a) Sewage water can be purified by passing it through sewage treatment plants with the action of microorganisms. A sewage treatment plant separates solids from liquids by physical processes and purifies the liquid by biological processes. There are three stages of this treatment; primary, secondary and tertiary. Primary treatment is physical, secondary biological and tertiary chemical.

Primary treatment phase of sewage treatment removes floating and suspended solids from sewage through two processes of filtration and sedimentation. First floating matter is removed through sequential filtration. The filtrate is kept in large open settling tanks where grit settles down. Aluminium or iron sulphate is added in certain places to flocculation and settling down of solids. The sediment is called primary sludge while the supernatant is called effluent. The primary sludge traps a lot of microbes and debris. It is subjected to composting or land fill where anaerobic digestion removes the organic matter.

During secondary treatment, the primary effluent is taken to aeration tanks. A large number of aerobic heterotrophic microbes grow in the aeration tank. They form flocs which are masses of bacteria held together by slime and fungal filaments to form mesh like structures. The microbes digest a lot of organic matter, converting it into microbial biomass and releasing a lot of minerals. As a result the BOD of the waste matter is reduced to 10-15% of raw sewage, which is then passed into settling tank. In settling tank, the bacterial flocs are allowed to undergo sedimentation. The effluent or supernatant is generally passed into natural water bodies and sediment of settling tank is called activated sludge.

(b) This treatment prevents water pollution and water borne diseases. So, it is essential in order to protect the natural water bodies from sewage pollution.

37. Prior to sowing rice, a leguminous crop was cultivated and ploughed back in the field. The root nodules of leguminous plants contain *Rhizobium* bacteria. *Rhizobium* is one of the most important source of biofertilizer. It forms an efficient symbiotic relationship with leguminous plants and can fix upto 100 – 500 kg nitrogen per hectare of land. The fixed nitrogen is used up by the leguminous plants. However, a sizeable amount of fixed nitrogen is left behind in the soil in the form of residue which can be utilized by the succeeding crop.