

SCIENCE

Chapter 2: Microorganisms: Friend and Foe






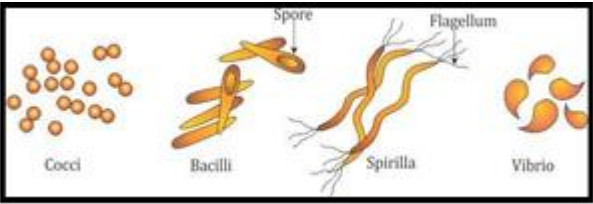
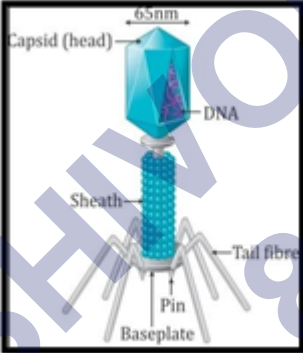
Microorganisms: Friend and Foe

Microorganisms

- Organisms too small to be seen with our naked eyes are called **microorganisms** or **microbes**.
- They can only be seen using a microscope.
- Microorganisms are found in a variety of habitats such as air, soil and water.
- They can live and survive in extreme environments, from ice cold regions to hot springs, from deserts to marshy lands.
- Some microorganisms are useful to us in many ways. They are called **beneficial microbes**. Example: Bacterium *Rhizobium* helps in nitrogen fixation.
- Some microorganisms cause diseases in plants, animals and human beings. They are called **pathogens**. Example: *Anthrax* bacillus causes anthrax in animals.
- Robert Hooke and Anton Van Leeuwenhoek discovered the existence of microbes during the period 1665 - 1683.

Major Groups of Microorganisms

GROUP	DESCRIPTION
Algae  <p>Blue-green algae Diatoms</p>	<ul style="list-style-type: none"> • Found on walls, in fields and in small puddles. • May be unicellular or multicellular with a size of 1 μ-1 m. • <i>Oscillatoria</i>, <i>Nostoc</i> and <i>Anabaena</i> are examples of this type of algae. • Sexual reproduction occurs by conjugation.
Fungi 	<ul style="list-style-type: none"> • Grows on stale bread, chapati, pickles, damp clothes and shoes in monsoon. • Respires aerobically or anaerobically. • Lives a saprophytic or parasitic life. • <i>Mucor</i>, <i>Rhizopus</i> and <i>Aspergillus</i> are examples of fungi.

<p>Protozoa</p>	<ul style="list-style-type: none"> • <i>Amoeba</i>, <i>Paramecium</i> and <i>Plasmodium</i> are examples of protozoa. • <i>Amoeba</i> has an irregular shape. • Locomotion occurs through pseudopodia. • <i>Paramecium</i> is slipper shaped.
	<ul style="list-style-type: none"> • It has numerous cilia for locomotion. • <i>Plasmodium</i> is a protozoan living a parasitic life. It is responsible for the spread of malaria.
<p>Bacteria</p> 	<ul style="list-style-type: none"> • Found in any kind of environment from deserts to Polar Regions. • Range in size is from 0.2 to 10 μ. • Reproduces sexually and asexually. • Respires aerobically or anaerobically. • Main types of bacteria according to their shape are Coccus, Bacillus, Vibrio and Spirillum. • <i>Rhizobium</i> and <i>Lactobacillus</i> are examples of bacteria.
<p>Virus</p> 	<ul style="list-style-type: none"> • Smallest microorganisms which can grow and develop only inside the host cell. • In free-living form, viruses are like non-living particles. • Viruses are classified into three types based on the type of host they infect. • Examples: Animal viruses: Foot and Mouth Disease Virus (FMDV) Plant viruses: Tobacco Mosaic Virus (TMV) Bacteriophage: Coliphage infecting <i>Escherichia coli</i>

Conditions Necessary for the Growth of Microorganisms



Useful Microorganisms

Increasing soil fertility

- Some bacteria and fungi act as decomposers and decompose dead and decaying matter and help in recycling nutrients back to the soil.

Cleaning the environment

- Microorganisms decompose complex organic matter such as waste of vegetables, fruits, plants and animals, and convert them into simpler substances, thereby cleaning the environment.

Retting of fibres

- Some bacteria carry out the process of loosening of fibres of plants by rotting, also called retting.

Tanning of leather

- During tanning, the bacteria attack the skin of animals. The protein structure of the skin undergoes a permanent alteration. This makes them soft and pliable and the skin is converted into leather.

Food industry

- Yeast helps in the commercial production of beer, wine and other alcoholic drinks by fermenting fruit juices, malted grains or molasses.
- Yeast is often used in the baking industry for making breads, pastries and cakes.
- Bacteria find application in the making of curd.
- Algae are a rich source of wholesome and nutritious food.

Production of antibiotics

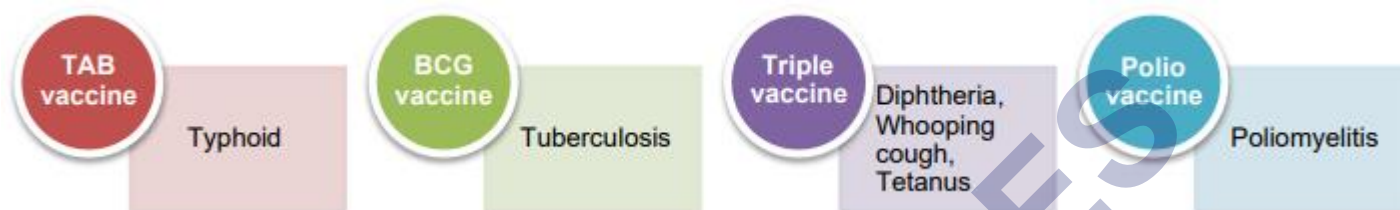
- Antibiotics are manufactured by growing specific microorganisms to treat a wide variety of diseases caused by pathogenic microorganisms.

Production of vaccines

- Vaccines are made on a large scale from microorganisms to protect human beings and other animals from several diseases.

- The first antibiotic penicillin was discovered by Alexander Fleming in 1929.
- Fungus *Penicillium notatum* produces penicillin.

Some Important Vaccines



Harmful Microorganisms

- Pathogens can successfully cause disease due to the following factors:
 - a. Ability to multiply fast.
 - b. Ability to destroy tissues of the body of other organisms.
 - c. Ability to produce toxins which affect certain organs of the host.

Communicable Diseases

- Microbial diseases which can spread from an infected person to a healthy person through air, water, food, physical contact or through vectors are called **communicable diseases**. Examples: Tuberculosis, chickenpox.
- The insects or other animals which transmit disease causing microorganisms to humans without themselves getting infected are called **carriers**. Examples: Housefly, mosquito.

Important discoveries

Alexander Fleming: Discovered penicillin in 1929

Louis Pasteur: Discovered fermentation in 1857

Edward Jenner: Discovered vaccine for smallpox in 1798

Robert Koch: Discovered bacterium *Bacillus anthracis* in 1876

Some of the Common Human Diseases Caused by Microorganisms

Disease	Causative microorganism	Mode of transmission	Preventive measures
Measles	Virus	Air	<ul style="list-style-type: none"> • Dirty, humid or overcrowded habitats should be avoided. • Vaccination should be given
Chickenpox	Virus	Air/Contact	
Polio	Virus	Air/Water	

Tuberculosis	Bacteria	Air	at the appropriate age.
Hepatitis A	Virus	Water	• Drink boiled drinking water.
Typhoid	Bacteria	Water	• Personal hygiene, cleanliness of the surroundings and consumption of well-cooked, nutritious food.
Cholera	Bacteria	Water/Food	
Amoebiasis	Protozoa	Water/Food/Flies	
Malaria	Protozoa	Mosquito bite	• Vaccination should be given at the appropriate age. • Population of mosquitoes should be reduced or eliminated.

Common Animal Diseases caused by Microorganisms

Disease	Animal affected	Causative microorganism
Anthrax	Cattle, sheep, elephant	Bacteria
Diphtheria	Guinea pigs, kittens, rabbits	Bacteria
Dysentery	Monkeys	Bacteria
Plague	Rats, squirrels, rabbits, guinea pigs	Bacteria
Tuberculosis	Monkeys, dogs, parrot, cattle	Bacteria
Lung necrosis	Adult cattle	Fungi
Foot and mouth disease	Split hooved animals	Virus
Swine flu	Pigs	Virus

Some Common Plant Diseases Caused by Microorganisms

Disease	Plant affected	Causative microorganism
Angular leaf spot	Cotton	Bacteria
Blight Canker	Paddy	Bacteria
Rust	Wheat	Fungi
Smut	Barley, wheat, oats, sugarcane, forage grasses	Fungi
Ergot	Corn, rye, wheat, bajra, barley	Fungi
Tikka disease	Groundnut	Fungi
Blast	Rice, ragi	Fungi
Late blight disease	Potato, tomato, black pepper, vanilla	Fungi
Sheath blight disease	Paddy	Fungi
Ring spot disease	Sugarcane	Fungi

Red rot disease	Sugarcane	Fungi
Yellow vein mosaic disease	Okra	Virus

Prevention of Communicable Diseases

Mouth and nose should be covered with a handkerchief while sneezing or coughing.

Uncovered roadside foods should not be consumed.

Food should be kept covered to protect it from getting infected by flies.

We should protect ourselves from mosquito bites by using mosquito nets or applying mosquito repellent creams.

Only boiled water must be consumed.

One must avoid sharing towels and combs.

There should not be stagnant water or open garbage dumps in the locality.

Food Poisoning

- Spoilage of food by the action of microorganisms is called **food poisoning**.
- It mostly occurs due to consumption of food spoilt by fungi and bacteria.
- When these organisms come in contact with food, they decompose it and release chemical toxins. This contaminates or spoils food.

Food Preservation

Food preservation is the process of treating and handling food in order to stop or slow down its spoilage while maintaining its nutritional value, texture and flavour.

Advantages of food preservation

- Reduces wastage of food
- Helps to transport food to distant places
- Helps to store food for use in

Principles of food preservation

- Keeping out food from the reach of microorganisms
- Removing microorganisms
- Inhibiting the growth of microorganisms

Methods of food preservation

- Boiling
- Salting
- Adding sugar
- Dehydration (Drying)
- Irradiation

Methods of Food Preservation

Boiling	•Boiling water kills all bacteria. Higher temperatures (110°C) kill spores
Salting	•Biodegradation is prevented under normal conditions
Preservation by sugar	•Reduces the moisture content which inhibits the growth of bacteria
Dehydration (Drying)	•Inhibits growth of microbes
Irradiation	•Radioactive or ultraviolet radiation kills microorganisms
Pasteurisation	•Heating to a temperature of about 60°C for 30 min and then chilling kills bacteria
Refrigeration	•Inhibits growth and multiplication of microbes
Chemical preservatives	•Sodium benzoate increases the concentration of solutes causing plasmolysis and death of bacteria and mould.

Nitrogen Fixation

- The process of converting nitrogen gas of the atmosphere into compounds of nitrogen which can be used by plants is called **nitrogen fixation**.
- **By nitrogen-fixing bacteria:** Ammonia is converted to nitrates by nitrifying bacteria.
- **By *Rhizobium* bacteria:** *Rhizobia* live in the root nodules of leguminous plants. They convert free nitrogen from the atmosphere into soluble nitrates.
- **By blue-green algae:** They fix nitrogen gas into ammonia, nitrates and nitrites.
- **By lightening:** During lightning, nitrogen and oxygen from the atmosphere combine to form nitrogen oxides which react with rainwater and form dilute nitric acid. Nitric acid reacts with the minerals present in the soil and forms nitrate.

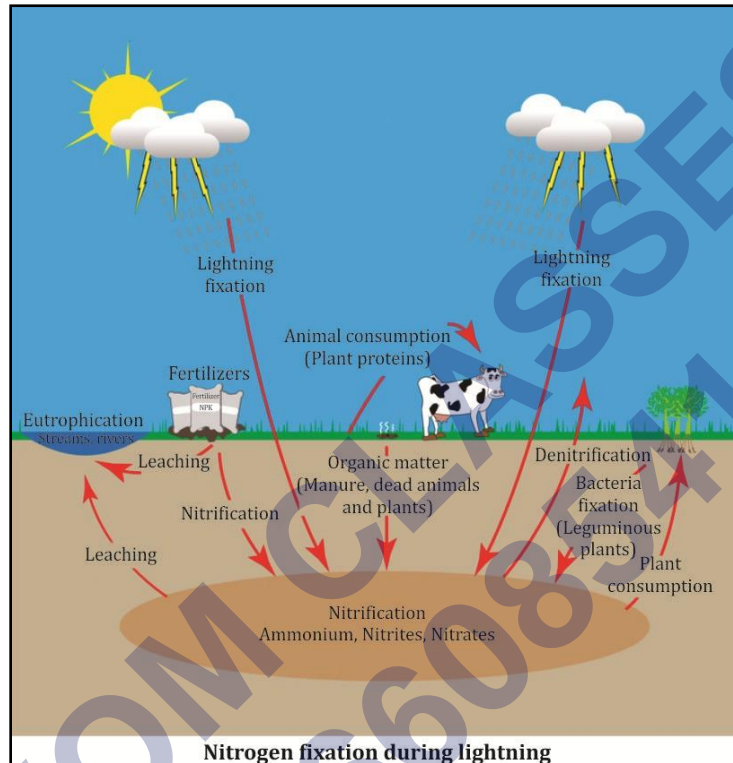
Nitrogen Cycle

- The process of circulation of nitrogen between the atmosphere, soil, plants and animals is called

the nitrogen cycle.

- Atmospheric nitrogen is fixed by biological nitrogen fixers as well as through physical processes such as lightning.

Nitrogen Fixation during Lightning



Oxides of nitrogen formed during lightening mix with rain water to form nitric acid. Nitric acid when mixes with minerals in the soil for nitrates.

Plants take up these nitrates and convert them into proteins. Animals consume plants.

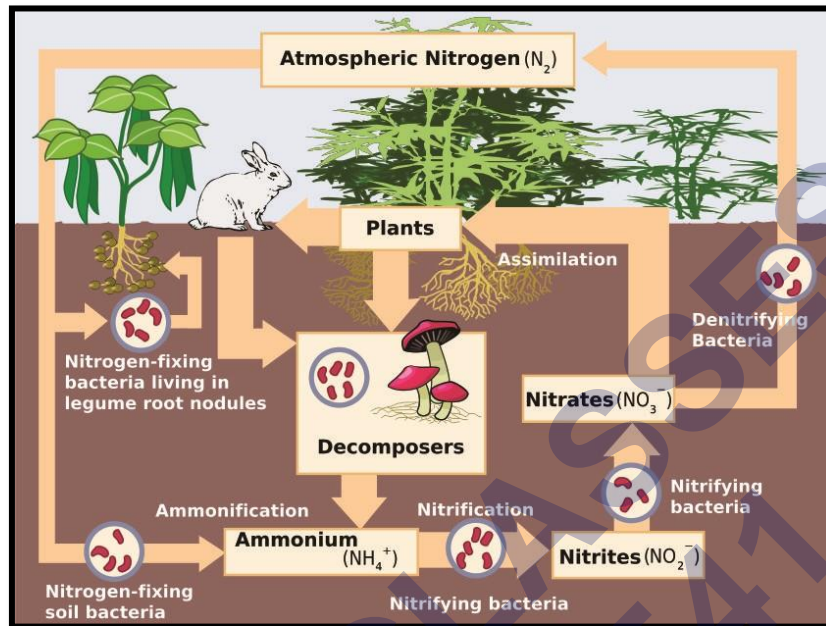
When plants and animals die, nitrogenous compounds present in their bodies are broken down into ammonia by ammonification.

Nitrifying bacteria such as *Nitrosomonas* convert this ammonia into nitrates by nitrification. Nitrates are stored in humus.

Sometimes nitrates are converted into molecular nitrogen by denitrifying bacteria *Pseudomonas*.

Due to constant recycling of nitrogen, the percentage of nitrogen in the atmosphere remains more or less constant.

Biological Nitrogen Fixation



Bacteria such as *Rhizobium* which live in the root nodules of leguminous plants convert free nitrogen into soluble nitrates.

This process makes the soil with nitrogen and increases its fertility. In return these bacteria get shelter from plants.

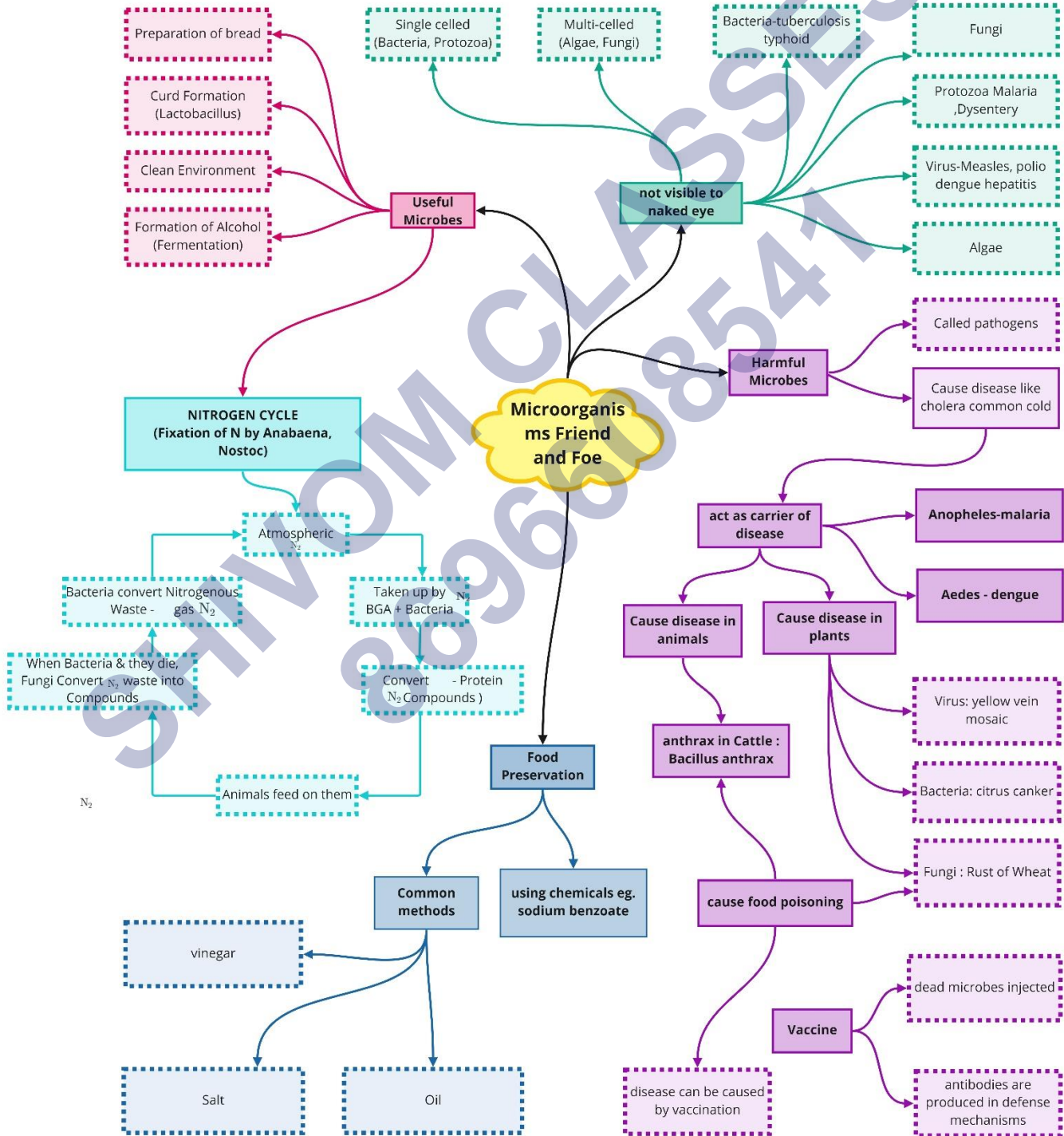
Some bacteria such as *Azotobacter* convert inorganic molecular nitrogen into amino acids and proteins.

Nitrogenous wastes from dead plants are converted back into ammonia by bacteria such as *Clostridium spp.*

Then ammonia is converted into nitrites by *Nitrosomonas* bacteria, and then into nitrates by *Nitrobacter*.

Nitrification is followed by denitrification, wherein nitrates are converted into nitrogen gas (N_2) by the action of denitrifying bacteria. The nitrogen gas is then released into the atmosphere.

Class : 8th Science
Chapter-2 Microorganisms Friend and Foe



Important Questions

Multiple Choice Questions-

Question 1.

The host for malaria causing protozoan is:

- (a) anopheles mosquito
- (b) the cow
- (c) the earthworm
- (d) the tapeworm

Question 2.

The bread or dosa dough rises because of the action of:

- (a) heat
- (b) grinding
- (c) growth of yeast cells
- (d) none of these

Question 3.

Malaria is spread by:

- (a) plasmodium
- (b) female anopheles mosquito
- (c) male anopheles mosquito
- (d) none of these

Question 4.

Protozoan shaped like a slipper is:

- (a) amoeba
- (b) paramecium
- (c) euglena
- (d) entamoeba

Question 5.

The bacterium that turns milk into curd is:

- (a) lactobacillus
- (b) acetobacter
- (c) rhizobium
- (d) none of these

Question 6.

The bacteria was first observed by:

- (a) Louis Pasteur
- (b) Antony Von Leuwen Hook
- (c) Robert Hooke
- (d) Robert Koch

Question 7.

Virus reproduce:

- (a) only outside the cells of the host organisms
- (b) only inside the cells of the host organisms
- (c) both inside and outside the cells of the host organisms
- (d) none of these

Question 8.

Which of the following lives alone:

- (a) amoeba
- (b) fungi
- (c) bacteria
- (d) all of these

Question 9.

The process of conversion of sugar into alcohol is known as:

- (a) pasteurisation

- (b) fermentation
- (c) decomposition
- (d) none of these

Question 10.

In Pasteurisation the milk is heated to about:

- (a) 100°C
- (b) 50°C
- (c) 70°C
- (d) 110°C

Question 12.

The bacterium living in the root nodules of leguminous plants is:

- (a) lactobacillus
- (b) acetobactor
- (c) rhizobium
- (d) none of these

Question 13.

Atmospheric nitrogen is used for the synthesis of:

- (a) plant proteins
- (b) animal proteins
- (c) plant carbohydrates
- (d) none of these

Question 14.

The percentage of nitrogen in the atmosphere:

- (a) increases during day time
- (b) decreases during day time
- (c) remains more or less constant
- (d) can't say

Question 15.

Which of the following is a preservative:

- (a) sodium benzoate
- (b) common salt
- (c) vinegar
- (d) all of these

Question 16.

Hepatitis-A is transmitted through:

- (a) water
- (b) air
- (c) food
- (d) contact

Question 17.

Communicable diseases are spread from an infected person to a healthy person through:

- (a) air
- (b) water
- (c) food
- (d) all of these

Question 18.

A group of micro organisms that have the characters of both living and non-living are:

- (a) bacteria
- (b) protozoa
- (c) virus
- (d) fungi

Question 19.

is the process by which alcohol and CO_2 are produced by yeast cells.

- (a) respiration

- (b) digestion
- (c) evaporation
- (d) fermentation

Question 20.

Cause of malaria is:

- (a) fungi
- (b) bacteria
- (c) protozoa
- (d) virus

Question 21.

The algae commonly used as fertilisers are called:

- (a) chlorellin
- (b) blue-green algae
- (c) spirogyra
- (d) none of these

Question 22.

Which of the following drug is an antibiotic?

- (a) alcohol
- (c) streptomycin
- (b) insulin
- (d) none of these

Question 23.

Leprosy is caused by:

- (a) bacteria
- (c) virus
- (b) protozoa
- (d) fungi

Question 24.

The cause of whooping cough is

- (a) bacteria
- (c) virus
- (b) fungi
- (d) algae

Question 25.

Virus is.

- (a) non-living
- (c) living as well as non-living
- (b) living
- (d) none of these

Question 26.

Tuberculosis is a disease caused by:

- (a) bacterium
- (b) protozoan
- (c) virus
- (d) malnutrition

Question 27.

BCG vaccine is used to curb:

- (a) cholera
- (b) tuberculosis
- (c) polio
- (d) typhoid

Question 28.

Cholera is due to:

- (a) virus

- (b) fungus
- (c) protozoan
- (d) bacterium

Question 29.

Which of the following is air-borne disease:

- (a) typhoid
- (b) tuberculosis
- (c) cholera
- (d) polio

Question 30.

Breathing in polluted air causes:

- (a) kidney trouble
- (b) heart problem
- (c) respiratory diseases
- (d) none of these

Question 31.

Yeast helps in the production of:

- (a) sugar
- (b) alcohol
- (c) oxygen
- (d) none of these

Very Short :

1. Name the five groups of microorganisms.
2. Name any two serious diseases caused by virus.
3. Name any two diseases caused by protozoa.
4. Name any two domestic uses of microorganisms.
5. Which bacteria promotes the formation of curd?
6. Name the bacteria used in making bread, pastries and cakes.

7. Name the commercial use of yeast.
8. Name the scientist who discovered penicillin.
9. Name any two communicable diseases.
10. Name any two carriers of diseases.
11. Name any two food preservatives.
12. Name the nitrogen fixation bacteria.
13. Who discovered pasteurisation?
14. Why milk is boiled before storage and consuming?

Short Questions :

1. What are microorganisms?
2. Define virus.
3. Why are viruses different from other microorganisms?
4. Where are microorganisms found?
5. How do microorganisms help in agriculture?
6. What is fermentation?
7. Why is yeast used in the baking industry for making bread, cakes and pastries?
8. What are antibodies?
9. What are communicable diseases?
10. Name the modes of transmission of communicable disease.

Long Questions :

Question 1.

Explain why antibiotics do not work against flu or any infection caused by viruses.

Question 2.

Mention any three ways through which pathogens are transmitted.

Question 3.

Explain canning.

Question 4.

Explain how malaria is transmitted to humans.

Question 5.

Explain various types of bacteria.

ANSWER

MCQ:

1. Anopheles mosquito

Anopheles mosquito is the host for malaria causing protozoan

2. Growth of yeast cells

Due to growth of yeast cells, the breads or dosa dough rises

3. Female anopheles mosquito

Malaria is spread by female anopheles mosquito.

4. Paramecium

Protozoan shaped like a slipper is paramecium.

5. Lactobacillus

Lactobacillus turns milk into curd.

6. Antony Von Leuwen Hook

The bacteria was first observed by Antony Von Leuwen Hook.

7. Only inside the cells of the host organisms

Virus reproduce only inside the cells of the host organisms.

8. Amoeba

Amoeba lives alone whereas fungi and bacteria live in colonies.

9. Fermentation

Fermentation is the process of conversion of sugar into alcohol.

10. 70°C

In pasteurisation the milk is heated to about 70°C for 15 to 30 seconds and then suddenly chilled and stored.

11. Rhizobium

The bacterium living in the root nodules of leguminous plants is Rhizobium.

12. Plant proteins

Atmospheric nitrogen is used for the synthesis of plant proteins

13. Remains more or less constant

The percentage of nitrogen in the atmosphere remains more or less constant.

14. All of these

Sodium benzoate, common salt and vinegar are all preservatives.

15. Water

Hepatitis-A is transmitted through water.

16. Water

Communicable diseases are spread from an infected person to a healthy person through air, water, food and physical contact.

17. Virus

Virus have the characters of both living and non-living.

18. Respiration

Respiration is the process by which alcohol and CO_2 are produced by yeast cells.

19. Protozoa

Protozoa called plasmodium is the cause of malaria.

20. Blue-green algae

Blue-green algae are used as fertilisers because they can fix atmospheric nitrogen to usable compounds which help in crop growth and improves the water holding capacity of soil.

21. Streptomycin

Streptomycin drug is an antibiotic

22. Bacteria

Bacteria causes leprosy.

23. Bacteria

Bacteria is cause of whooping cough.

24. Living as well as non-living

Virus is living as well as non-living.

25. Bacterium

Tuberculosis is caused by bacterium.

26. Tuberculosis

BCG vaccine is used to curb tuberculosis.

27. Bacterium

Bacterium causes cholera.

28. Cholera

Tuberculosis is an air-borne disease.

29. Respiratory diseases

Breathing in polluted air causes respiratory diseases.

30. Alcohol

Yeast helps in the production of alcohol.

Very Short-

1. **Ans:** Five groups of microorganisms are bacteria, fungi, protozoa, algae and virus.
2. **Ans:** Polio and chickenpox are caused by viruses.
3. **Ans:** Dysentery and malaria are caused by protozoa.
4. **Ans:** Two domestic uses of microorganisms are as follows:
 - Setting of curd,
 - Fermentation of idlis.
5. **Ans:** Lactobacillus promotes the formation of curd.
6. **Ans:** Yeast is used in making bread, pastries and cakes.
7. **Ans:** Yeast is used in the production of alcohol and wine.
8. **Ans:** Alexander Fleming discovered penicillin.
9. **Ans:** Cholera and common cold.
10. **Ans:** Two common carriers of diseases are mosquitoes and houseflies.
11. **Ans:** Two food preservatives are sugar and vinegar.
12. **Ans:** Rhizobium is the nitrogen fixation bacteria.
13. **Ans:** Louis Pasteur.
14. **Ans:** Milk is boiled to prevent spoilage due to development of microorganisms.

Short Answer-

1. **Ans:** Extremely small living organisms that cannot be seen by naked eye are called microorganisms. They may be unicellular or single-celled or multicellular.
2. **Ans:** Viruses are tiny transferable agents that act as non-living outside host cells and act living inside host cells and show reproduction. Viruses can affect all kinds of organisms including animals, plants and bacteria.
3. **Ans:** Viruses are also tiny but are different from other microorganisms as they show reproduction. They reproduce inside the host cell which may be a bacterium, plant or animal.
4. **Ans:** Microorganisms are found in all kinds of environments, ranging from ice cold climate to hot springs; and deserts to marshy lands. They are also found inside the bodies of animals and humans. Some microorganisms grow on other organisms while others exist freely.

5. **Ans:** Microorganisms increase the soil fertility by combining the air, nitrogenous compounds and minerals. Bacteria like Rhizobium and blue green algae are microorganisms which can fix atmospheric nitrogen in the soil and increase soil fertility, which helps in agriculture.
6. **Ans:** Fermentation is the process in which conversion of sugar into alcohol takes place through the action of enzymes.
7. **Ans:** Yeast reproduces quickly and produces carbon dioxide during respiration. Yeast makes breads, cakes and pastries soft and spongy. This is the basis of using yeast in the baking industry.
8. **Ans:** An antibody is a protein released by the body's immune system in response to the microbes carrying diseases in our body. Antibody provides the strength to fight against the disease-causing microbe. Antibodies protect our body against infectious diseases.
9. **Ans:** Infectious diseases that can spread from an infected person to a healthy person through mediums like air, water, food or physical contact are known as communicable diseases. Examples of communicable diseases are cholera, common cold, chicken pox and tuberculosis.
10. **Ans:** The modes of transmission of communicable diseases can be direct and indirect. In direct transmission diseases can be spread by direct contact, by droplet infection, sharing infected needles, syringes and razors, infected blood transfusion. In indirect transmission diseases can be spread by infected food, water or air, through carriers like the housefly, mosquitoes, and rats or through dirty hands.

Long Answer-

1. Answer:

Viruses cannot be killed by using antibiotics as their cell pathways are different from that of bacteria. It means taking antibiotics to get rid of flu or any other viral infection is useless, because it does not reduce the strength of the virus, nor does it reduce the duration of the infection. But, however, antibiotic will work if we get attacks of viral infection and bacterial disease at the same time. Even then, it will cure bacterial disease only but not the viral infection.

2. Answer:

Three ways because of which pathogens are transmitted are as follows:

- (i) When a person sneezes or coughs, tiny droplets containing a number of disease-causing microorganisms come out of the mouth, and are released in the air. They are transmitted to a healthy person while breathing.
- (ii) By making direct contacts with an infected person, pathogens are transferred to a healthy person.

- (iii) Carriers of pathogens also help in their transmission. For instance, when a fly sits on animal excreta or garbage, harmful disease-causing microbes stick to its legs. And when this fly sits on the food items, pathogens get transferred to them. This contaminated food items cause serious diseases when it is eaten by a healthy person.

3. Answer:

Canning is a process used for food preservation. Heat, at a certain temperature and for a limited period of time, is used to kill the harmful microorganisms as well as enzymes. This method also involves the removal of oxygen gas, and to avoid post-process contamination by airtight sealing of food items.

4. Answer:

A protozoan called Plasmodium is responsible for malaria. It lives in the liver and blood of the person who has been infected by this disease. A female Anopheles mosquito when sucks blood from the infected person, Plasmodium along with blood, is taken into its stomach. The Plasmodium, here, multiplies itself and reaches the salivary gland of the mosquito. Now, when this mosquito bites a healthy person, it injects Plasmodium along with saliva to him. The healthy person then gets an attack of malaria. In this way, malaria is transmitted to humans.

5. Answer:

Bacteria are classified on the basis of their shapes into the following categories:

- Rod-shaped bacteria (bacilli): These are aerobic rod-shaped, spore-producing bacteria. They are often occurring in chain-like formations, and they are found primarily in soil; e.g., Lactobacillus.
- Spherical-shaped bacteria (cocci): They are spherical or nearly spherical bacteria; e.g., Streptococcus.
- Curved-shaped bacteria (vibrios): They are curved-shaped bacteria; e.g., Vibrio.
- Spiral-shaped bacteria (spirilla): They are flagellated, aerobic bacteria, having a spirally twisted rod-like form; e.g., Treponema.