9 Economic Importance of Bacteria and Fungi

Syllabus : Economic importance of Bacteria

Useful role of bacteria. — medicine : antibiotics, serums and vaccines; Agriculture : nitrogen cycle (role of nitrogen fixing, nitrifying and denitrifying bacteria). Industry : curing of tea, tanning of leather.

Harmful role of bacteria. Spoilage of food, diseases in plants and animals, bio-weapons.

Economic importance of Fungi.

A brief idea of the useful role of Fungi in breweries, bakeries, cheese processing, mushroom cultivation (Processes of manufacture are not required).

(A) ECONOMIC IMPORTANCE OF BACTERIA

Bacteria are primitive organisms consisting of single cells (prokaryotes, without a true nucleus). They have no chlorophyll and their body is not differentiated into parts like root, stem, leaves and flowers. **[*According to the recent Five Kingdom classification the bacteria are not plants, the reason being that they have no chlorophyll and the mode of nutrition in them is heterotrophic instead of autotrophic.*]**

9.1 BACTERIA – A GENERAL STUDY

The bacteria are *most primitive unicellular* organisms. Each bacterial cell contains **a single chromosome** (nuclear material) which is **not enclosed in a nuclear membrane.**

Bacteria — so numerous and everywhere.

There are several thousand known species of bacteria which occur in air, water, soil, food-stuffs, on or inside the body of living organisms, and in short, practically everywhere. **In our own body** there are hundreds and thousands of bacteria in mouth, on skin, inside intestines, in the genital tracts, etc. Some bacteria occurring in our intestine are beneficial, they synthesise certain vitamins, such as vitamin B. Certain bacteria are highly injurious causing diseases, but there are others which are highly beneficial.

[According to one estimate, there are more bacteria normally living on your skin than the total number of humans living on Earth. These bacteria are even useful as they prevent the growth of harmful ones]

Size. Bacteria are the smallest living organisms on earth, with an average size of 2 micrometres long and 0·5 micrometre thick (1 micrometre = one-thousandth of a millimetre).

Shape. Shape-wise, the bacteria are usually of four types :

(1) **Cocci** (spherical bacteria),
(2) **Bacilli** (rod-shaped bacteria),
(3) **Spirilla** (spiral or twisted bacteria),
(4) **Vibrio** (comma-shaped).

Many bacteria live single but some occur in pairs **(diplococci)**, or in long chains **(streptococci)** or in clusters **(staphylococci)** (Fig. 9.1).

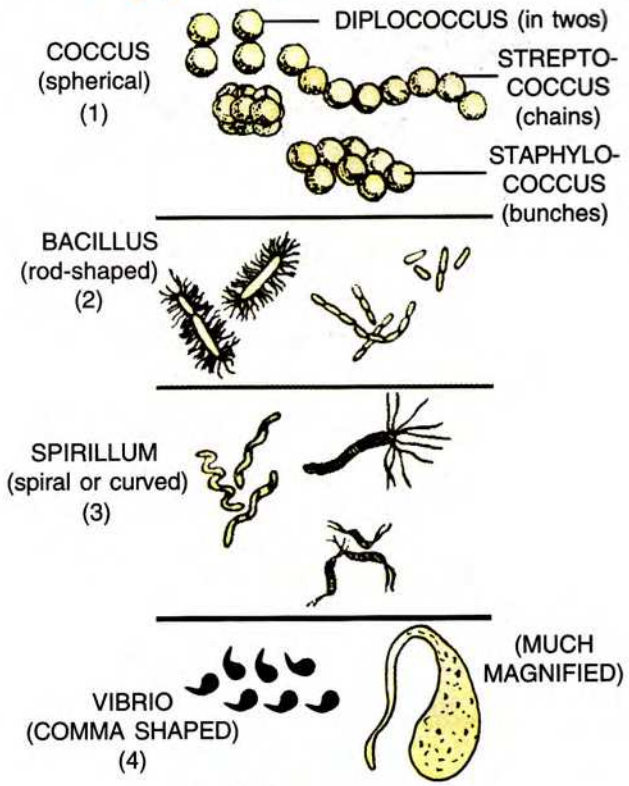


Fig. 9.1 Kinds of bacteria

Structure. Each individual bacterium is rather a simple cell (Fig. 9.2).

— It contains the living substance **protoplasm/ protoplast lying within the cell membrane** (cytoplasm + bacterial chromosome) surrounded by a non-living stiff **cell wall.** The cell wall is made of peptidogylcan and not of cellulose (as in plant cells).

— A thin **cell membrane** lies immediately beneath the cell-wall and surrounds the **cytoplasm.**

— There is no well-defined nucleus but **chromatin (DNA) material is present in the central region.** This chromatin material is in the form of a single circle and is not enclosed in a nuclear membrane, but is attached to the cell membrane at some point.

— The cytoplasm contains vacuoles, granules and, in very few cases, some green pigment as well.

— Sometimes a slimy protective layer called **capsule** is present outside the cell wall.

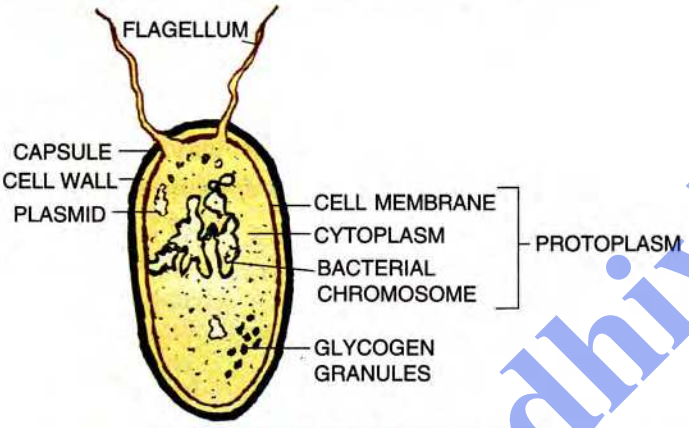


Fig. 9.2 Bacterial cell (diagrammatic)

Movement. Most bacteria cannot move about by their own effort and they are only passively transported by wind, water or contact. But some bacteria possess one or more whip-like flagella which pierce through the cell-wall and capsule. The lashing movements of the flagella provide active locomotion in a liquid environment.

Nutrition. Most bacteria have no chlorophyll, therefore, they depend on readymade food from different sources **(heterotrophic).** In this category, the bacteria may be :

- **saprotrophic** (drawing nourishment from decaying dead organisms), or
- **parasitic** (drawing nourishment from the body of their living hosts).

The bacteria secrete powerful enzymes from their cells into the surrounding food-containing material. The enzymes make the food material soluble which is then absorbed as a solution into the bacterial cell.

Respiration. Some bacteria respire by absorbing atmospheric oxygen **(aerobic),** others need no free oxygen **(anaerobic).** The anaerobic bacteria are killed if exposed to air.

Reproduction. Reproduction in bacteria is only **asexual** by means of fission or cell division. The circular DNA duplicates. The cell expands and the two DNA are pulled apart. The cell constricts at the middle separating the two cells (Fig. 9.3). Depending on the type of bacteria the two daughter cells may either remain attached or may separate from each other as independent cells.

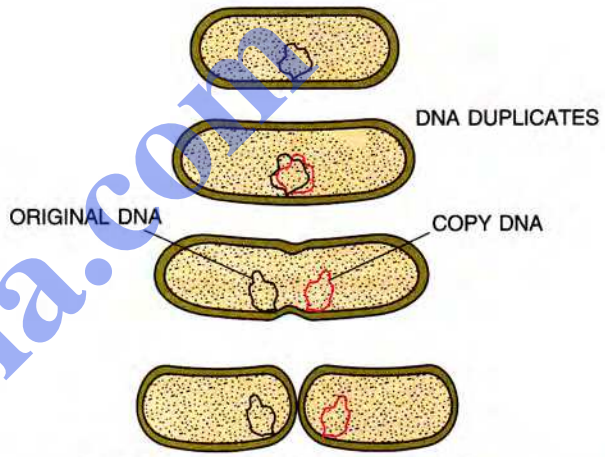


Fig. 9.3 Reproduction in bacteria by fission

BACTERIA REPRODUCE VERY FAST

Under ideal conditions some bacteria divide at a very fast rate, once in every half an hour. At this rate of growth and division starting with a single bacterium, at the end of 24 hours there would be 281,514,871,750,656 bacteria!

Highly primitive type of sexual reproduction has been found in very few bacteria and is extremely simple. In this method two bacteria of different strains (but of the same species) come together (conjugation). The plasmid of the donor may be transferred into the recipient through a hollow tubelike extension of the donor cell.

Spores to overcome unfavourable conditions. When unfavourable conditions set in, such as the drying up of vegetation, the bacterial cell draws its content into a spherical mass which becomes surrounded by a thick and hard protective wall. This little rounded body is a **spore** which is contained

within the original cell-wall (Fig. 9.4), but later becomes free when the cell-wall ruptures. Such spores are usually the resting stages which can withstand unfavourable conditions.

- These can **tolerate extreme dryness**,
- Some **cannot be killed** even at the temperatures of boiling water or frozen ice,
- Some can **tolerate poisonous chemicals**.

The spores can be carried far and wide by various means such as wind, water or contact. On meeting favourable conditions the spores germinate, their dormant protoplasm becomes active and streams out of the ruptured wall in the form of a new bacterium.

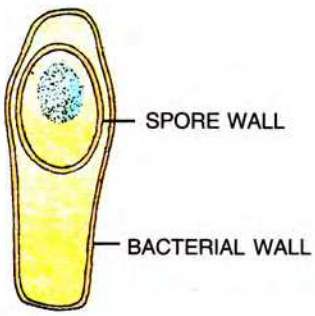


Fig. 9.4 A bacterium forming a spore inside itself.

[Spore-formation in bacteria is not a method of reproduction but simply a method of escaping unfavourable conditions]

PROGRESS CHECK

1. Name the three common shapes of bacteria.
2. Give the technical terms for the following patterns of occurrence of bacteria
   (i) In pairs _____
   (ii) In long chains _____
   (iii) In clusters _____
3. List the kinds of nutrition in bacteria.
   _____
4. What is the common method of reproduction in bacteria ?
   _____
5. Why do bacteria produce spores ?
   _____

9.2 USEFUL ROLE OF BACTERIA IN MEDICINE

Bacteria are used in medicine in the production of antibiotics, serum and vaccines.

9.2.1 ANTIBIOTICS

An antibiotic is a chemical substance produced by a living organism which can stop the growth of some disease-producing bacteria and fungi.

Today, we know of dozens of antibiotics widely used in the treatment of numerous infections. *Examples* : **streptomycin, chloromycetin, tetracycline, penicillin**.

Penicillin — The first produced antibiotic (from a fungus and not bacterium). How it was discovered is described below.

In 1929 Alexander Fleming observed that some bacteria growing in a culture were destroyed by an accidental contamination of a mould *Penicillium notatum* (Fig. 9.11 p. 99). He discovered that this mould produced a substance which suppressed the growth of many bacteria, and the substance was named *penicillin*, the first antibiotic for medical use. But remember, penicillin is the product of a mould (fungus) and not of a bacterium.

Next antibiotic *streptomycin* was discovered by Selman Waksman in a similar way. Its source organism was the bacterium *Streptomyces griseus*.

Some well-known antibiotics, their sources and the diseases treated are as follows :

Antibiotic	*Source organism*	*Disease treated*
Penicillin	*Penicillium chrysogenum* (a mould)	Tetatus, Diphtheria
Streptomycin	*Streptomyces griseus*	Tuberculosis
Chlorotetracycline	*Streptomyces aureofaciens*	Typhoid
Ehythromycin	*Streptomyces erytheraeus*	Rickettsial fevers

Criteria for a good antibiotic

1. It should be able to kill a variety of disease-producing microorganisms ("broad spectrum" antibiotic).
2. It should not produce undesirable side-effects.
3. It should not kill normal bacteria of the host.

Other uses of antibiotics

- As food preservatives, especially for fresh meat and fish.
- For treating animal feed.
- For controlling plant pathogens.

9.2.2 SERUMS

Serum actually means blood plasma from which fibrinogen has been removed. It may contain numerous chemical substances including anti-bodies/anti-toxins, etc.

Toxins are poisonous proteins released by pathogenic bacteria during their growth or on their breakdown after they die.

Serums contain antitoxins (chemical substance) of a particular pathogen. Serums are used as a preventive measure against bacterial invasion. For preparing serum, a small dose of **bacterial toxin** is introduced into the blood of a healthy animal such as horse or cow. The body produces antitoxins to neutralise the effect of toxin. After several injections of the same toxin the blood of such animal is taken out. On chilling, it clears as straw colour liquid which separates out from the clot and is called **serum.** Snake-bite treatment involves injecting the particular anti-venine produced from the blood of horses, etc., in the same manner as given above.

Genetic engineering has made it possible to introduce the human genes in certain bacteria like *Escherichia coli* (*E. coli*). These bacterial cultures grow very rapidly. The particular gene dependent products are extracted from these bacteria. The hormone **insulin was the first such substance produced by** *E. coli*.

A few serum compounds produced by genetically modified bacteria are :

- Blood clotting factor VIII for the treatment of Haemophilia A.
- Factor IX for the treatment of Haemophilia B.

9.2.3 VACCINES

Vaccine : A preparation consisting of weakened can germs or dead germ substances.

Vaccination : Introduction of weakened germs or dead germ substances into the body for developing resistance to a particular disease.

Vaccines are available for a variety of diseases such as cholera, typhoid, measles, chickenpox, *etc.* On injecting them into the body the person gets the disease in mild form and his body gets stimulated to produce **antitoxins.** The antitoxins provide immunity against any future attack of the particular disease germs.

Antitoxin. A substance produced in animal bodies which reacts with the poison (toxin) produced by the invading germs.

Two common vaccines obtained by growing bacteria are as follows :

Killed bacteria — for TAB vaccine for *typhoid.*

Living weakened bacteria — for BCG vaccine for *tuberculosis.*

9.2.4 TOXOIDS

Toxoids are the inactivated toxins of the particular bacteria, which can still stimulate the production of the respective antibodies such as those for producing immunity against *diphtheria* and *tetanus*

[**Note :** You will find a more detailed account of vaccination and immunization in your Class-X text-book].

9.3 BACTERIA – ROLE IN AGRICULTURE

9.3.1 NITROGEN-FIXING BACTERIA

A special category of soil bacteria **(Rhizobium)** are found living in small nodules on the roots of leguminous plants such as beans (Fig. 9.5). These bacteria pick up free nitrogen from the soil atmosphere and convert it into soluble nitrates. These nitrates are used by the host plant and also by other plants sown later in the same soil.

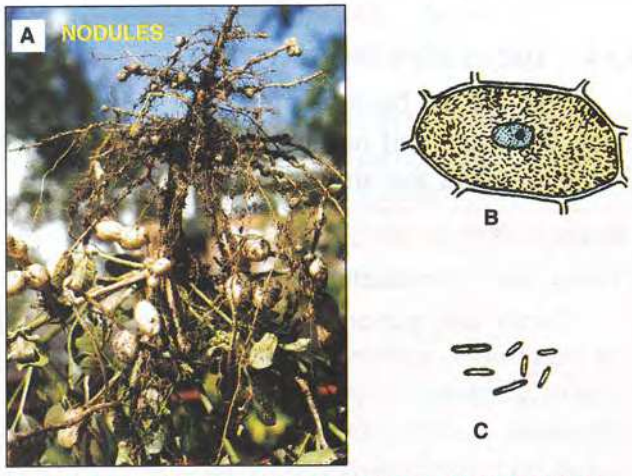
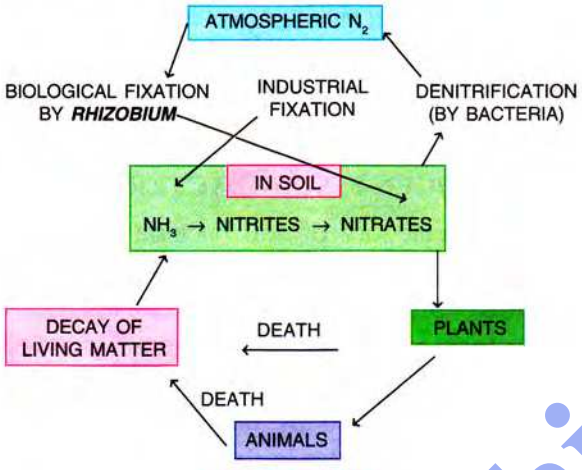


Fig. 9.5 A—The roots of a leguminous plant showing nodules; B—Section of one of the nodules containing bacteria; C—The bacteria taken out from a nodule

9.3.2 Certain free living bacteria in the soil like Azotobacter, Clostridium etc. use the free nitrogen of the soil and convert it to ammonia with hydrogen which in turn gets converted to aminoacids and nitrates, enriching the soil.

9.3.3 NITRIFYING BACTERIA

Plants need nitrogen for synthesising proteins, but they cannot make use of the free atmospheric nitrogen. They can obtain it only in the form of **nitrates**, which they absorb from the soil through roots. These nitrates are replenished in the soil by bacteria through the process of ***nitrification***. For this, some bacteria first convert the nitrogenous wastes of animals and the dead remains of plants and animals into ***ammonia***. Ammonia is then converted into ***ammonium compounds*** which in turn are first converted into ***nitrites*** by bacteria such as ***Nitrosomonas*** and then into ***nitrates*** by bacteria such as ***Nitrobacter***. Each of these steps is brought about by specific bacteria.



Nitrogen cycle.

9.3.4 DENITRIFYING BACTERIA

These are the bacteria present in the soil, which break down the soil nitrates to release nitrogen gas (N_2) that enters the atmosphere.

Extra – Not in Syllabus

Decay and Putrefaction by bacteria

Decay and putrefaction are the greatest uses of bacteria in nature. Thousands of animals and plants are **dying** every moment and every living organism is eliminating organic **excreta**. Bacteria act on their dead bodies and on the excreta and break them down into simpler chemical compounds such as nitrates, sulphates, carbon dioxide, which in turn are utilized by the plants for their growth.

Decay is the *complete breakdown* of organic matter by bacteria without giving out a foul smell; for example, the cowdung exposed to air is reduced to soil in a few days.

Putrefaction is the *incomplete breakdown* of organic matter by bacteria, emitting a foul smell.

There are **sewage treatment plants** in big cities (Delhi has one such unit) where the collected human excreta is decomposed by sewage bacteria. A gas is produced in the process which can be collected for cooking, and the liquid and solid products are used as manure in agricultural fields.

The *"gobar" gas* plants better called **biogas plants** are also designed on the same principle. Fermenting bacteria degrade cellulose of the cow dung and release inflammable gases mainly consisting of methane. The practice of installing biogas plants is serving a dual purpose— (i) supply of fuel and (ii) supply of rich manure.

Synthesis of vitamins and digestion

Several bacteria habitually live in our intestines where they synthesize certain vitamins especially of B complex group and vitamin K. In herbivorous animals the bacteria help in the digestion of cellulose.

9.4 BACTERIA — ROLE IN INDUSTRY

Bacteria have a very extensive use in industry. You have already read about their role in producing certain types of medicines on a large scale. Here are two more out of several other uses.

(1) Different ***flavours of tea*** are produced by certain bacteria (this is termed tea curing).

(2) ***Leather tanning*** is primarily brought about by sunlight but certain bacteria break down the soft perishable parts of skin (hide).

9.5 SPOILAGE OF FOOD BY BACTERIA

Many bacteria spoil cooked food, milk, fruit, vegetables, *etc.*, by the process of decay (fermentation) particularly during summer. This spoilage may sometimes be to the extent of causing **food-poisoning. Botulism** is a very serious food poisoning due to a special bacterium sometimes found in tinned and sealed foods (the affected cans get distended at their ends with gas which gushes out on opening — such suspected foods should be completely discarded. Therefore, ***preservation of food*** and ***making it free of disease-germs*** is very necessary.

Food preservation can be brought about by several methods :

1. **Boiling or heating at high temperatures (Sterilization) :** Boiling water kills all bacteria except their spores. Higher temperatures (about 110° C) at increased pressure (as in autoclave, or in pressure-cooker) kill even the spores. The canning industry employs heating to kill bacteria before packing and sealing food.
2. **Salting :** Salting is a common method of preserving foods like fish, pickles, etc., for long periods of time. By mixing these foods with salt their bio-degradation is prevented under normal conditions. Treatment with salt for preservation purposes is called curing.
3. **Dehydration (Drying) :** Most microbes cannot grow without water. Therefore, dehydration by drying of foods such as grains, meat, fish, vegetables is an effective method of preservation. Dried milk powder is another excellent example.
4. **Irradiation :** Radioactive radiation has been tried in sterilizing certain foods without themselves becoming radioactive, but the practice is not yet in much use. Similarly, **ultra-violet** light is found useful, not only in sterilizing the air in schools, hospitals and factories, but also in killing mould spores in bakeries.
5. **Pasteurization :** Pasteurization is a technique of partial sterilization applied usually to milk. The milk is heated to a temperature of about 60°C for a period of 30 minutes and then chilled quickly. Pasteurization kills a majority of the bacteria that are present, including the disease-causing ones. Remember, **pasteurization does not completely sterilize milk.** Souring bacteria may still be present in it, but by keeping the milk sufficiently cool, they do not multiply.
6. **Refrigeration (cold temperature) :** Microbes (bacteria and moulds) do not grow and multiply at or below the freezing point of water. Chilling of milk and keeping vegetables and fruit in a cold storage are popular methods of preserving them. Frozen fish or frozen vegetables keep fresh for a long time. Domestic refrigerator cools at 0 - 5°C for short-term storage. Deep freezing cools at –20°C to –30°C for long term storage.
7. **Strong concentration and chemicals :** Jams and pickles do not get spoiled. They have a strong concentration of sugar and salt respectively. The increased concentration of the solutes causes plasmolysis and death of any bacteria, or mould that may creep in. Sometimes preservatives like sodium benzoate are also added to tinned foods and squashes.

9.6 BACTERIAL DISEASES IN PLANTS AND ANIMALS

A. In Plants

Two very common diseases of plants caused by bacteria are *black rot* of mustard and cauliflower and *bacterial blight* of cowpea ("lobia").

B. In Animals

Two common bacterial diseases of cattle among animals are :

1. **Anthrax** — Swelling on body and reduced milk yield
2. **Tuberculosis** — Lungs affected, dry husky cough

C. In Humans

Some common bacterial diseases of humans are as follows :

Whooping cough, cholera, tuberculosis, diphtheria, typhoid, pneumonia, tetanus. (For more details on bacterial diseases in humans, see Chapter 18.5).

9.7 BIOWEAPONS

It has come to knowledge that some countries may be preparing 'germ bombs' which when exploded may simply release disease germs such as **Anthrax** bacteria which may take epidemic shape and cause widespread death generation after generation.

POINTS TO REMEMBER

- ***Bacteria are the most primitive form of the living organisms***
- ***Bacteria are variously shaped : spherical (cocci), rod-shaped (bacilli), spiral shaped (spirilla) and vibrio (comma-shaped).***
- ***Most bacteria are heterotrophic (parasitic or saprophytic)***
- ***Bacteria form spores to overcome unfavourable conditions***
- ***Bacteria are useful in many ways—decay and putrefaction, nitrification, nitrogen-fixation, synthesis of vitamins, cellulose digestion in certain animals, fermentation, source of medicines, etc.***
- ***Several bacteria are harmful in spoiling food and causing diseases like cholera, typhoid, etc. in humans and bacterial rot in agricultural crops, and also diseases like anthrax and tuberculosis in cattle.***

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

1. Bacteria are no more classified as plants primarily because :
   (a) these are unicellular
   (b) these are microscopic
   (c) many of them are parasitic
   (d) they have no chlorophyll.
2. A particular species of which one of the following, is the source bacterium of the antibiotic, discovered next to penicillin, for the treatment of tuberculosis?
   (a) *Escherichia* (b) *Streptomyces*
   (c) *Rhizobium* (d) *Nitrobacter*
3. Which bacteria is rod shaped ?
   (a) Coccus (b) Spirillum
   (c) Bacillus (d) Vibrio
4. Which bacteria fixes nitrogen in the soil ?
   (a) Nitrobacter (b) Nitrosomonas
   (c) Rhizobium (d) Clostridium

B. VERY SHORT ANSWER TYPE

1. **Name** the three common types of bacteria.
2. **Match** the items in Column A with those in Column B.

Column A	Column B
(i) *Penicillium*	(a) Bacteria occurring in chains.
(ii) Diplococci	(b) Antibiotic.
(iii) Streptococci	(c) Bacteria occurring in pairs.

C. SHORT ANSWER TYPE

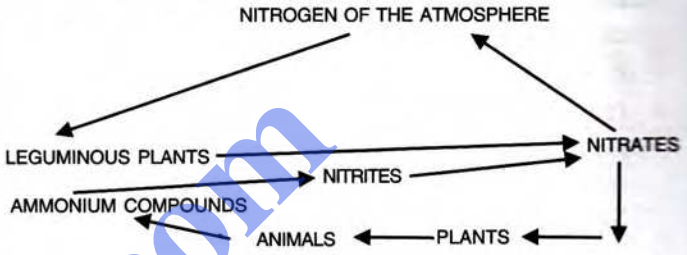
1. Would you consider the bacteria and yeast as plants? Give reason.
2. In what form bacteria may be present in the air?
3. Why is spore formation in bacteria not considered a form of reproduction ?
4. In what respect do you consider bacteria as simple organisms ?
5. State the **differences** between
   (a) Decay and putrefaction.
   (b) Pasteurization and sterilization.
6. Why is it generally advised that every living room in the house should get direct sunlight at least for a short time ?
7. Would there be any bacteria in an aquarium ?

D. LONG ANSWER TYPE

1. Both bacteria and yeast reproduce by asexual method, but how does this method differ in them ?
2. Describe the role of micro-organisms in industrial production
3. How do bacteria obtain their nourishment ?
4. Describe any *two* uses of bacteria in industry.
5. What are antibiotics ? Name any *two* examples.
6. Is tinned and sealed food *always* safe to eat? Give reasons in support of your answer.

E. STRUCTURED/APPLICATION/SKILL TYPE

1. Study the diagram given below and then answer the questions that follow :



   (a) Briefly describe how nitrogen of the atmosphere is converted to nitrates by leguminous plants.
   (b) Name the bacteria that converts (i) ammonium compounds to nitrites (ii) nitrites to nitrates.
   (c) State how the nitrates in the soil get converted to nitrogen of the atmosphere.
   (d) Role of plants and animal in the formation of ammonium compounds.

WOULD THERE BE ANY BACTERIA IN AN AQUARIUM ?

A balanced aquarium contains certain animals as well as some plants. How many kinds of animals can you make out in the aquarium shown here ? Name any two such animals.

.....

.....

Do you think there would be some bacteria in it ? If so, in which part of the aquarium would they be occurring in abundance and what for ?

.....

(B) ECONOMIC IMPORTANCE OF FUNGI

Before we discuss the economic importance of fungi, it will be useful to know about their general features. Fungi have **no chlorophyll** and their body is not differentiated into parts like the root, stem, leaves and flowers. However, compared to bacteria the fungi are more highly evolved (eukaryotes, with a true nucleus) and multicellular. [*According to the recent Five Kingdom classification, the fungi are not plants, the reason being that they have no chlorophyll and the mode of nutrition in them is heterotrophic instead of autotrophic.*]

9.8 FUNGI – A GENERAL STUDY (Not in syllabus but useful to know)

The most common fungi are the **moulds** which grow on our food, bread, fruit and even on leather and on barks of trees. **Mushrooms** and **toadstools** are a common sight in the warm, rainy season. Most mushrooms are **poisonous** but **some are edible**.

MOULDS

Rhizopus (Fig. 9.6) is the common bread mould. It grows not only on bread but also on a variety of other organic matter such as fruit, animal dung and leather goods, in warm and humid climate. It consists of a network of transparent thread-like structures called **hyphae** and the entire mass of these threads is called **mycelium.** The penetrating hyphae secrete certain enzymes which digest the food in the bread substratum **(extracellular digestion)** and absorb it.

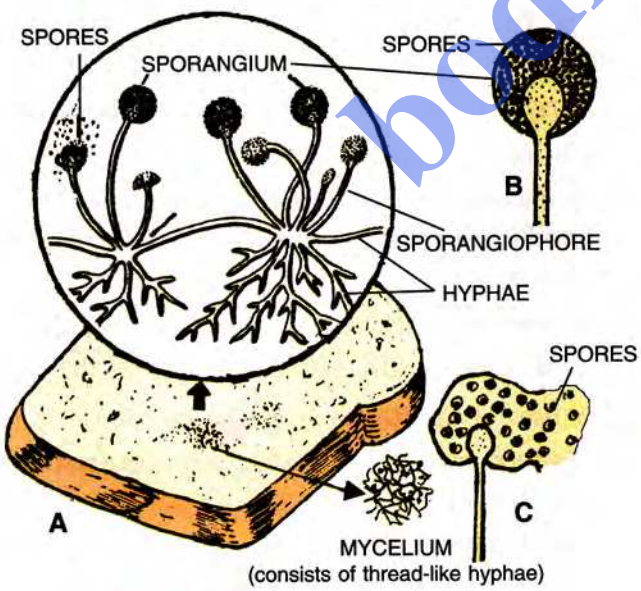


Fig. 9.6 A—*Rhizopus* growing on bread, B—A mature sporangium, C—A sporangium bursting to release spores

Reproduction in bread mould is both asexual and sexual. **Asexual reproduction** starts within a few days of the growth of the mycelium. Some hyphae become erect **(sporangiophores)** and swell up at their tips. The swollen tip is called **sporangium** that turns dark as the spores inside get matured.

The sporangium bursts to liberate spores which are scattered by wind. Falling on a suitable substratum the spores germinate if there is suitable warmth and moisture, and form a new mycelium.

YEAST*

Yeasts are generally in the form of separate spherical cells.

There are several species of yeast under the genus *Saccharomyces*. All yeasts are one-celled fungi. They occur either singly or in the form of budding chains.

Occurrence. Yeasts are found freely in the atmosphere. They readily grow in all kinds of sugary solutions and in any plant exudations containing sugar. They grow readily on grapes, in the nectar of flowers, in sugar cane juice, *etc*.

Structure. The yeast cell (Fig. 9.7) is ovoid in shape, has a distinct cell wall and a nucleus. There may be one or more vacuoles in the cytoplasm.

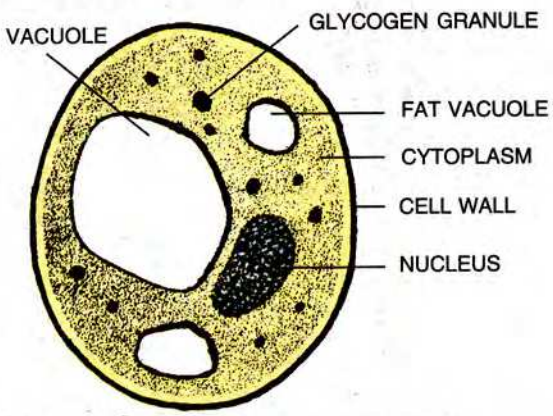


Fig. 9.7 A single cell of yeast (diagrammatic)

* The syllabus does not specify inclusion of yeast in this unit. However, we are describing the yeasts for enrichment, because yeasts are widely used in bakeries and breweries, both of which are included under the scope of syllabus.

Nutrition. Yeast cell can directly absorb simple sugar (glucose) but the cane sugar or sucrose has to be first broken into simple sugar by one of the enzymes before absorption into the cell.

Respiration. Yeast respires anaerobically in the absence of air, *i.e.* without using oxygen. The respiratory equation proceeds as follows :

$$\underset{\text{(glucose)}}{C_6H_{12}O_6} \rightarrow \underset{\text{(ethanol)}}{2C_2H_5OH} + 2CO_2 + 2ATP$$

ECONOMIC IMPORTANCE OF YEAST

Yeast's greatest importance to mankind is through its property of **alcoholic fermentation.** The alcohol (ethanol) produced is of great commercial importance. When produced for beverages, the quality of alcohol varies with the material fermented but also with the kind of yeast employed.

9.9. USEFUL AND HARMFUL FUNGI

A. USEFUL FUNGI

Several species of *Penicillium* are used in processing fine flavoured cheeses.

One of its species *Pencillium notatum* is most notable as the source of the first wonder drug antibiotic **penicillin** (p. 92) (discovered by Alexander Fleming).

B. HARMFUL FUNGI

Most fungi are harmful. They spoil food. Many cause damage to forest trees. *Penicillium* and *Aspergillus* (Fig. 9.8) are two common moulds popularly called blue and green mould respectively. They grow on oranges, lemons and other citrus fruits. There are some fungi that cause diseases such as ringworm.

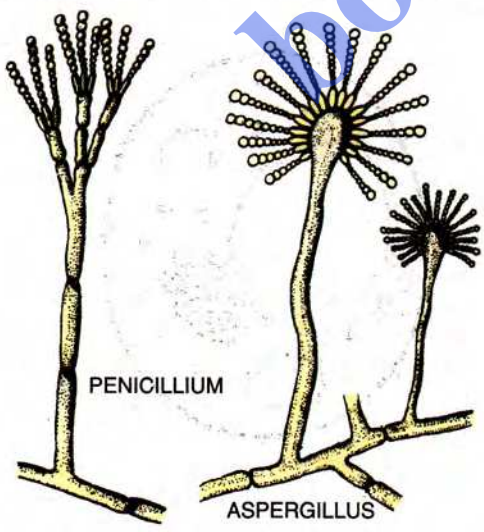


Fig. 9.8 Two common moulds which grow on fruits (Highly magnified)

Next time you happen to see a greenish fungus growing on the outer skins of overripe/rotting oranges or lemons, be sure it is some species of *Penicillium*. But certainly do not be under the impression that it can be used as "penicillin"

Fig. 9.9 Penicillium growing on orange

9.10 USEFUL ROLE OF FUNGI

ANTIBIOTICS

An antibiotic is a chemical substance produced by a living micro-organism which can stop the growth of or kill other micro-organisms.

The first antibiotic was penicillin produced by a mould. You have read about it in the earlier pages.

To refresh your knowledge about antibiotics.

Criteria for a good antibiotic

1. It should be able to kill a variety of disease-producing microorganisms ("broad spectrum" antibiotic).
2. It should not produce undesirable side-effects.
3. It should not kill normal bacteria of the host.

Other uses of antibiotics

- As food preservatives, especially for fresh meat and fish.
- For treating animal feed.
- For controlling plant pathogens.

9.11 FUNGI – ROLE IN INDUSTRY

Fungi have a very extensive use in industry. Here we will talk about a large number of practices that are quite old and traditional and some that are rather recent.

9.11.1 WINE – AN ALCOHOLIC BEVERAGE

Wine and other alcoholic beverages like beer, are the products of the process called **fermentation**.

> **Fermentation** is a process in which the micro-organisms (yeast and bacteria) break down carbohydrates into simpler products (ethanol or lactic acid) in the absence of oxygen.

The source used for making wine is grape and for beer it is barley maltose, and the micro-organism employed is yeast (*Saccharomyces cerevisiae*).

The biochemical reaction is as follows :

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \rightarrow \underset{\text{Ethanol (ethyl alcohol)}}{2C_2H_5OH} + CO_2$$

Grapes are crushed and fermented in large vessels. Yeast cells that may be naturally present on the grapes or added carry out the process. Ethanol (ethyl alcohol) is produced at a concentration of about 12%, and this concentration starts killing yeast cells. What is left is wine. [Spirits such as whisky and gin, which have a much higher alcohol content, are obtained by distillation of the fermented mixture].

Wines contain variable amount of water, alcohol, carbon dioxide, sugar and a few other substances.

Characteristics of wine :

- Wine is quickly absorbed into the body.
- In very mild quantities it may be a stimulant but when consumed in large quantities it is **harmful** in many ways.
- Alcoholics may develop body ailments, particularly **liver cirrhosis.**

9.11.2 BAKING (BREAD-MAKING)

In baking a mixture of flour (atta or maida), some fat, salt and water is required to make "dough", the starch of the flour gets converted into sugar. When the yeast is added, it ferments the sugar and produces carbon dioxide and the dough "rises" **(leavening)** to about three times its orginal volume. When the dough is baked the gas bubbles expand and give the bread a light "spongy" texture.

9.11.3 CHEESE

Cheese is a valuable food with high quantities of protein, some fat, together with calcium and phosphorus, and vitamin A with some quantities of vitamin B.

People have been eating cheese for centuries. It has been made from milk. The manufacture of cheese includes the following major steps :

1. **Curdling of milk** by addition of lactic acid bacteria (*Lactobacillus*). Curd produced is separated from whey.
2. **Curd is processed** to remove moisture. At this stage it is called **cottage cheese.**
3. **Salting** — This further removes moisture, and prevents growth of undesirable micro-organisms.
4. **Ripening** — The curd is kept at suitable temperature and humidity. The micro-organisms added along with lactic acid bacteria at step 1, impart particular flavours to the cheese.

> **Extra**
>
> **Some other industrial uses of bacteria**
>
> - Bacteria are used in the production of **vinegar** and in the **processing** of coffee, tobacco, etc.
> - The fibres for making rope, linen, etc., are obtained by loosening the fibres of hemp and flax by **retting** (a kind of rotting by bacteria).
> - **Curing of hides** and **skins** is also done with the help of bacteria.

9.11.4 MUSHROOM CULTIVATION

Mushrooms are of various shapes and size. Many have cap and stalk, but in some varieties stalk is absent. There are a large number of mushroom species which grow wild in nature.

Not all mushrooms are edible. In fact, most are mildly or severely poisonous. The edible ones have been eaten by humans since ancient times. *Agaricus bisporous* is the most common edible mushroom eaten practically all over the world. At present, three kinds of mushrooms are widely cultivated in India and abroad :

1. White button mushroom ***(Agaricus bisporous)***

CULTIVATED BUTTON MUSHROOM

MOREL

PUFFBALL (DISPERSING A CLOUD OF SPORES)

Fig. 9.10 Three edible fungi

2. Paddy straw mushroom (*Volvariella*)
3. Oyster mushroom (*Pleurotus*)

Mushroom cultivation is done indoors and hence little land area is required. Mushrooms can be grown on substrate or compost based on various agricultural wastes which in turn are recycled [Compost : decayed organic matter used for fertilising land].

White button mushroom (*Agaricus bisporous*) is the most popular variety grown in India. Its cultivation involves five major steps– (i) composting, (ii) spawning, (iii) casing, (iv) cropping and harvesting and (v) preservation.

(i) ***Composting :*** The compost is prepared by mixing the following in certain proportions.

- Wheat or paddy straw,
- Chicken manure
- Some organic and inorganic fertilizer

The compost is kept at about 50°C for about one week.

(ii) ***Spawning :*** "mushroom seed" consisting of mycelium of the selected type of mushroom is introduced into the compost, and allowed to spread for a couple of days.

(iii) ***Casing :*** A thin layer of soil is spread over the compost. This is a very important step. It

- gives support to the mushroom
- provides humidity
- prevents quick drying of the compost
- helps to regulate temperature.

Some precautions

1. Arrangement has to be made for circulating air around the beds.
2. Temperature has to be kept low (20-25°C) for preventing growth of pests and diseases.

(iv) ***Cropping and Harvesting :*** The growth occurs in three principal stages :

- Mycelium (a network of fibrous mass) grows within 2 to 6 weeks.
- Tiny pin heads.
- Button stage which grows bigger attaining marketable size.

The full grown mushrooms are taken out.

(v) ***Preservation :*** Mushrooms are highly perishable. Their shelf life is increased by a variety of processes :

- Vacuum cooling
- Giving gamma radiation & storing at 15°C
- Freeze drying in a solution of citric acid, ascorbic acid and brine, *etc*.

Nutritive value of mushrooms : Mushrooms are excellent source of vitamins and minerals. They contain a good amount of **niacin, pantothenic acid** and **biotin**. The vitamins in mushrooms are well retained during cooking, canning and dehydration. Fresh mushroom contains about 85–95% moisture, 3% protein, 4% carbohydrate, 0·3–0·4% fat and 1% minerals and vitamins.

CAUTION : Never try eating mushrooms from the field. They may be poisonous and even fatal. Buy them only from reliable shops which obtain their supplies from a mushroom farm.

?

PROGRESS CHECK

1. Which is the most common variety of cultivated mushroom ? _____
2. What is meant by "mushroom seed" ? _____
3. What is done in the step called "casing" ? _____

POINTS TO REMEMBER

- ***Bread mould (Rhizopus) is the commonest fungus.***
- ***Moulds obtain their nourishment through extra-cellular digestion (saprophytism) from the substratum on which they grow.***
- ***Moulds reproduce both asexually and sexually— asexually through spores produced directly and sexually through a zygospore produced as a result of the union of gametes from two mycelia of different strains***
- ***Some moulds are sources of antibiotics.***
- ***Wine (alcohol) is produced by fermenting sugar (glucose) with yeast (Saccharomyces cerevisiae).***
- ***Mushroom culture includes the steps of composting, spawning, casing, cropping-harvesting and preservation***

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

1. Production of ethanol (C_2H_5OH) occurs in one of the life processes of :
   (a) Bread mould (b) Yeast
   (c) Mushroom (d) *Penicillium*
2. Which one of the following characteristics is found in *all* fungi but not in all bacteria ?
   (a) Aerobic respiration
   (b) Cell wall
   (c) Spore formation
   (d) A long circular DNA lying loose in the cytoplasm.
3. Bacteria are refered to as prokaryotes because:
   (a) They have no chlorophyll
   (b) They are unicellular
   (c) They are free living
   (d) They do not have a true nucleus.
4. Yeast is used in the production of :
   (a) Ethyl alcohol (b) Acetic acid
   (c) Cheese (d) Curd

B. VERY SHORT ANSWER TYPE

1. Tick (✓) mark the **correct** statement/statements.
   (a) All mushrooms are poisonous.
   (b) All toadstools are poisonous.
   (c) Some toadstools are poisonous.
   (d) Some mushrooms are edible.

C. SHORT ANSWER TYPE

1. Where can the mould *Rhizopus* be **most easily** found ?
2. Why is it generally advised that every living room in the house should get **direct sunlight** at least for a short time ?
3. Describe the role of certain fungi in **industrial production**.
4. Mention two useful and two harmful efects of wine.
5. Differentiate between :
   (a) Saprophyte and Parasite
   (b) Aerobic and anaerobic respiration with regard to products
   (c) Decay and putrefaction.

D. LONG ANSWER TYPE

1. What are antibiotics ? Name any *two* examples.
2. Is tinned and sealed food *always* safe to eat? Give reason in support of your answer.
3. Would there be any bacteria in an aquarium ?

E. STRUCTURED/APPLICATION/SKILL TYPE

1. If you leave a piece of moist bread covered under a small bell jar at a warm place, mould grows on it in a few days. Answer the following with reference to this observation :
   (a) How did the mould get inside the bell- jar?
   (b) What would happen if the bread was not covered by the bell-jar ?
   (c) What would happen if moist bread was placed in a refrigerator ?
   (d) What appears first on the bread—the mycelia or the spores ?
   (e) How does bread mould obtain nourish-ment ? What type of nourishment is it—epiphytic, autotrophic, parasitic symbiotic, or saprophytic?
2. Write in **proper sequence** the five major steps in the cultivation of the common edible mushroom.
3. Comment on the following :
   (a) Denitrifying bacteria are a blessing as well as a curse to farmers.
   (b) Yeast is used in bakeries and breweries.