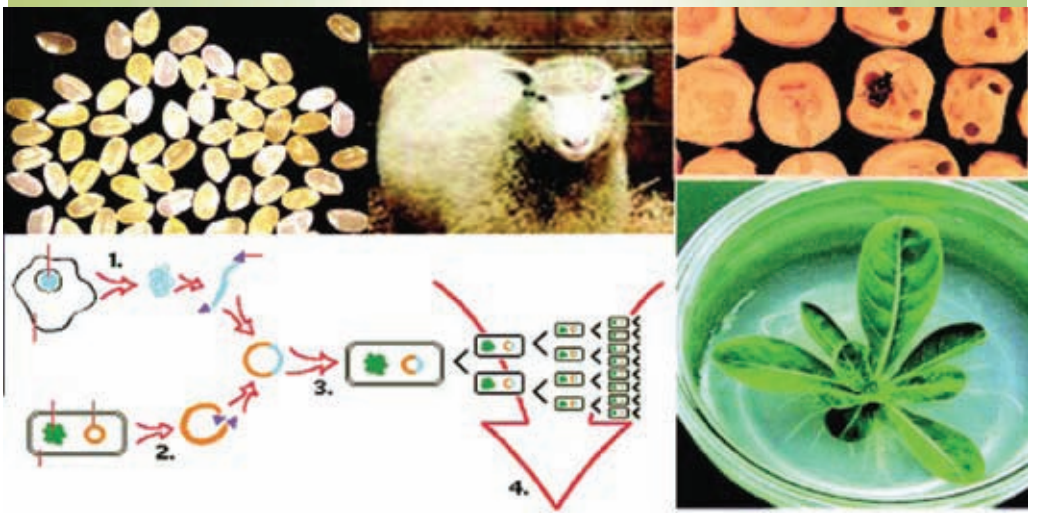
5. New trends in biology



At the end of this Chapter, you will be competent to...

- Investigate the contribution of Microbial technology and Molecular biotechnology in the fields of agriculture, industry, medicine and rehabilitation of ecosystems in order to improve the quality of human life.

5.0 New trends in biology

The field of Biology that increased at a great pace in the present period is in the field of bio-technology. As the name suggests this field is a hybrid of biology and technology.

From the distant past, man has used biotechnology in certain activities of his life such as breeding animals and plants; producing food materials by fermentation, extracting medicines and other useful substances from plants.

Biotechnology can be called the improvement and utilization of biological systems and biological activities in order to make maximum use from them, for man and other organisms. For the convenience of studying , the field of biotechnology has been divided into two areas, namely

1. Microbial biotechnology
2. Molecular biotechnology

5.1 Microbial biotechnology

This scientific field deals with utilizing the activities of microorganisms for the benefit of man. Man has for a long time used microbial activities for various purposes.

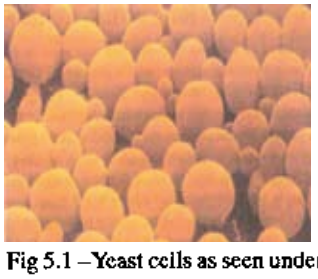


Fig 5.1 –Yeast cells as seen under the microscope

A common example for this is the use of the microorganism yeast found in sugar solutions, for making alcohols such as toddy, wine and beer. This is a result of the anaerobic respiration taking place in yeast cells.

Here,glucose is broken down in the absence of oxygen to form ethanol, CO_2 and energy.

$$2\,C_6H_{12}O_6 \longrightarrow 2\,C_2H_5OH + 2\,CO_2 + \text{energy}$$

Glucose Ethanol

The above activity of microorganisms is known as fermentation.

Do you know?
In day to day activities ethanol is used as a solvent, fuel and a coolant.

Activity 5.1

Studying fermentation.

Method

Place some sugar solution in a test tube. Add some yeast. Observe the colour, smell and other chandes in this sample for five days at a stretch. Discuss your observations with your teacher.

Fig. 5.2 Holes in bread due to the action of yeast

The evolution of CO_2 gas during anaerobic respiration of yeast is also used by us in our daily life. The rising of the 'dough' in the preparation of bread and hoppers is due to CO_2 gas remaining in the dough as bubbles. This gives a porous quality to the mixture. The activity given below will clarify this.

Activity 5.2

Studying the expansion in size of dough due to yeast

Materials needed: Wheat flour, yeast, sugar, graph paper, glass plate (about the size of an A4 paper)

Method:

Mix some flour, sugar, yeast with some water and make a sough that will not stick to your fingers. Place the graph paper on the table and keep the glass plate over it. Keep the dough in the middle of the glass plate and spread to the size of , 4cm x 4cm x 0.5 cm. Note the area of the dough using the graph paper, at 30 min. intervals.

Use of microorganisms for dairy products

Various kinds of Bacteria have been widely used in the production of milk products over the past. *Streptococcus lactis* and *lactobacillus bulgaricus* are two species of bacteria used in cheese and yoghurt making.

Use of microorganisms for getting fibre from plant sources

Microorganisms have been used for separating fibre by exposing certain plants to a process of fermentation over the past. *Clostridium* bacteria, under anaerobic conditions produces an enzyme pectinase. This causes the middle lamella of the cells to break down making it easy to separate the fibres.Examples for this are getting fibres from coconut husk and hemp fibres from hemp leaves.

Modern microbial technology

Modern day practices in the field of microbial technology has spread to many areas such as agriculture, industry, medicine, and rehabilitation of ecosystems.

Use of microorganisms in agriculture

Nitrogen is one of the essential elements in plant growth. Although 78% of the atmosphere consists of nitrogen, plants cannot make use of it directly. There are microorganisms which can convert this nitrogen to organic materials during their biological activities. This process is called nitrogen fixation. An example of such a kind of bacteria are the *Rhizobium* species of bacteria found in the root nodules of leguminous plants.

Activity 5.3
Carefully uproot a *Mimosa* plant (of the Leguminous family) and observe the nodules in the roots. Make a sketch of it and label it.

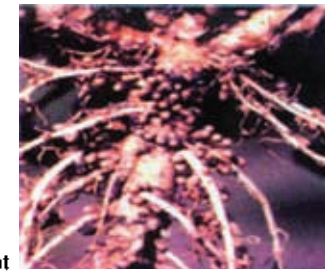


Fig 5.3 Root nodules of a Leguminous plant

It has been found that certain kinds of bacteria which can fix nitrogen in this way live freely in the soil too. The rate at which nitrogen is supplied to the soil by such natural methods is not sufficient to fulfill the present day needs in the agriculture sector. Therefore the demand for artificial chemical fertilizers is on the increase. Chemical fertilizers are made using mineral oils. Hence as the price of mineral oil increases, the price of such fertilizers also rises.In order to face this challenge, scientists are involved in finding ways and means of using microbiological techniques to provide the necessary nitrogen to the plants. Some attempts in this direction are as follows:

1. Introducing the genetic material of the *Rizobium* bacteria in root nodules to commercially important plants.
2. Introducing genetically improved nitrogen fixing bacteria (Biofertilisers) by biological techniques, to the soil in an agricultural land.
3. Introducing improved nitrogen fixing bacteria to the soil before planting of seeds (Rhizobial inoculation). This improves the growth of root nodules and plant growth. This is practiced successfully in Soya bean vegetations.

Biological pest control

Pests are organisms which cause damage to crops. Important among them are insects and their larvae. Although they can be controlled with chemical pesticides it has many harmful results. One such example is the harmful consequences of using D.D.T as a pesticide which eventually had to be banned from use.

Now, scientists have been successful in introducing genetically improved varieties of bacteria to destroy the pests causing damage to crops. Lepidoptera

larvae are destroyed using the poisonous protein produced by the bacteria, *Bacillus thuringiensis*. Here the tissues of the digestive system of the larvae are destroyed.

Controlling weeds

Unwanted plants growing in agricultural lands, ponds and water bodies are known as weeds. Although chemicals can be used as weedicides, it may cause mutations in plants as well as enter man and animals along the food chain, causing harm. Hence there are attempts to use microbial herbicides for weed control. An example of such an exercise was the use of the fungus Alternaria for controlling the aquatic plant, Salvinia. (Fig. 5.4)

Assignment 1
Find out the reasons for banning the use of D.D..T, and prepare a report.

Fig 5.4 Salvinia

Use of microbial biotechnology in industry

Most metals are extracted from ores. After extracting the metal from the metal rich ore using chemical methods, the remaining residues with small quantities of metal is thrown away. It is difficult to extract the metal from this residue, yet by microorganism activity, any remaining metal can be extracted.

This method is called Biomining. Two varieties of bacteria used for this purpose are *Thiobacillus thiooxydans* and *Thiobacillus ferrooxydans*. Metals such as copper, nickel, lead, zinc, gold, silver and uranium are extracted in this manner. Unlike in chemical extraction methods the harm to the environment by this method is minimal.

Copper metal is found as copper ferrous sulphide in the ores of copper. The above two kinds of bacteria belong to the group of chemosynthetic bacteria. These bacteria get their energy by oxidising ferrous ions to ferric ions. The sulphur is converted to sulphate ions by these bacteria. $CuSO_4$ is formed as a result of these reactions. Copper is obtained from copper sulphate by electrolysis.

The addition of enzymes to detergents used for washing clothes increases it's efficiency to remove food stains or blood stains which cling tightly to the cloth. Protease and Lipase are two such enzymes. These are obtained from improved varieties of microorganisms by biotechnological methods.

Use of microbial biotechnology in medicine

The cause of many of the diseases that affect us are due to bacteria. Antibiotics are used to destroy these bacteria. The microorganisms used in producing antibiotics are considerably improved by biotechnology.

The discovery of Penicillin by Sir Alexander Fleming was an important landmark in microbial biotechnology.

Assignment 2
Find information about the discovery of Penicillin by Alexander Fleming and prepare a reoprt

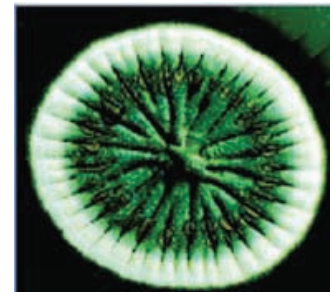


Fig.5.5 A culture of the fungus used for Penicillin production.

Many other antibiotics similar to Penicillin have now being prepared. Many of these are from natural microorganisms or varieties of improved using bio-technological methods. Production of Streptomycin by *Streptomyces griseus* bacteria and production of Tetracycline by *Streptomyces aureofaciens* are some examples for the above.

Use of biotechnology for environmental rehabilitation

Environmental pollution is increasing daily due to the increase in population and industrial development. Microorganisms improved by biotechnology can be used to convert the soil and water pollutants to a harmless form. This method is called Bioremediation. For this purpose species of *Pseudomonas* are often used. The conversion of urban garbage to compost by *Mycobacterium* and *Acinetobacter* bacteria, conversion of polluted water from industries to drinking water, and removal of oil spills on sea water by Bacilli and Aeromonas bacteria are some examples of the above.

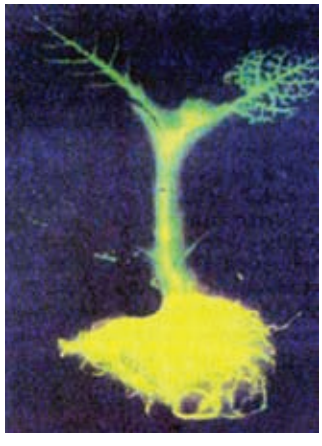
3.2 Molecular biotechnology

Before getting on to studying about molecular biotechnology, it is useful to recall some ideas about this field which you have learnt before. They are as follows:

- The basic building unit of organisms is the cell.
- The life functions of the organism is controlled by the nucleus of the cell.
- The nucleus contains chromosomes.
- The genes found on the chromosomes are responsible for determining the characters of the organism as well as carry them from generation to generation.

- Genes are found on chromosomes. A gene is a definite section of the DNA molecule where the genetic information about the organism is stored.
- An organism has one or more genes associated with a certain character.
- One gene produces one protein. The functional compounds of organisms such as enzymes and hormones are made up of proteins.
- The sum of all different genes in an organism is called the genome.

Recombinant gene technology



The discovery of technology for activities such as introducing the genes of one species to another species, changing the information stored in the gene etc. has enabled Genetic Scientists to change the genome of an organism.

This technology is called Recombinant DNA technology or Genetic Engineering. DNA are separated from the cell using enzymes and chemical substances

Fig. 5.6 shows a a bioluminescent Tobacco plant, made by introducing genes from the Fire-fly to Tobacco plant.

An organism used extensively for gene technology experiments is the bacteria, Esterichia coli. This bacteria has only one chromosome. In addition , there are small circular DNA molecules in the cytoplasm of the bacterial cell. These are called plasmids. When the bacteria cell grows and divides these plasmids too replicate, and enter the daughter cells. If any gene is introduced into the plasmid, during cell division that too will divide. The protein which was coded by this gene can be produced in large quantities using this bacteria.

This technique is presently used to produce insulin and human growth hormones. The process of DNA transformation is illustrated below.

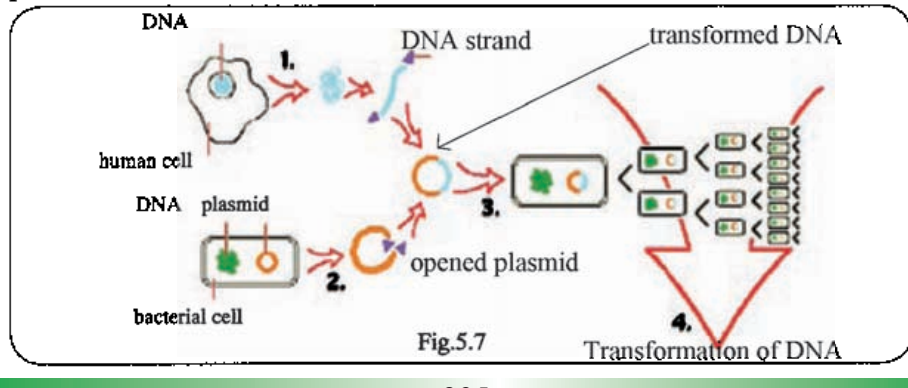


Fig.5.7

Since the DNA molecules of bacteria and virus are comparatively small it is easy to separate them. Although DNA is separated from the cell, their biological character is not changed. Hence they can be reintroduced into another living cell without change.

1. The selected gene is separated from the chromosome of a human cell using Restriction enzymes.
2. Plasmid is separated from the bacterial cell and the human gene is introduced to it.
3. The plasmid with the new gene is reintroduced into the bacteria.
4. The bacteria with the new gene divides and produces the required protein in large quantities.

Fig.5.8 Human insulin from bacteria

Assignment 3
Find out how insulin was made before using bacteria for producing it. Compare the two methods and write a report.

Improved varieties of organisms

- **Improved varieties of plants**

Some of the characters that are anticipated to be improved in plants by biotechnology are:

- Resistance to drought
- Resistance to harm from diseases and pests
- Improvement in the nutritive value and the taste of plant products.

In the past , such qualities were obtained by hybridization.There a large number of genes were exchanged. But in the modern biotechnological methods only the gene concerned is exchanged, hence is a more efficient method than the former.

An example of a recent attempt was the development of wheat varieties resistant to harmful weevils. It was estimated that 7% of the world wheat production was destroyed by these weevils.

Wheat plant was improved in this manner by the introduction of a resistant gene from the soil bacteria, *Bacillus thuringiensis*. Due to this gene a certain poison affecting the weevils was formed in the wheat plant.

Fig 5.9 Affected and unaffected seeds of wheat.

Till recently, farmers controlled this infection in the wheat plants by spraying the above mentioned bacteria with chemical pesticides.But this method was not very successful as the sprayed chemical was only effective for a few days of the insect's life cycle.

Biological technology has produced varieties resistant to virus, fungi and worm infections.

Further, plants have been improved to an extent to be unaffected by weedicides.A new variety of rice enriched with Vitamin A has been produced. It is called Golden Rice'. It is higher in nutritive value, than the traditional varieties.

Fig.5.10 Golden rice

- **Improved varieties of animals**

In the use of biotechnology on plants the emphasis was on getting animal products more easily. With that objective, scientists have been able to introduce new genes to the ovum or the embryo of animals. An example for this is using sheep to produce a protein that is very useful to man. Here the human gene producing that protein is selected and introduced into the nucleus of the ovum of the sheep. This ovum is fertilized and put back into the womb of the female sheep and allowed to grow. Some of the female sheep produced as a result contain the human gene and produce milk from which has the particular protein.

Given below are two examples where the above method was used.

1. Production of a drug 'alpha- 1- antitrypsin' which is used to treat the lung disease called emphysema.
2. Production of the drug ' Blood clotting factor V111'used for treating haemophilia patients

Experiments on the production of haemoglobin using pigs and thereby producing blood artificially are also successful. Hence the developments achieved in many directions in the field of Biotechnology are considerable. Through this, it should be possible to improve the quality of life of future mankind.

Exercises

1. Give 3 examples for each of the following where microbial activity has been used.
   a) Food production
   b) Agriculture
   c) Industry.

2. In what ways are organic fertilizers better than chemical fertilizers?

3. What are the qualities that can be improved by genetic engineering in
   a) Plants b) Animals

4. What are the a) Advantages b) Disadvantages of using biological pest control methods?

5. Discuss how recombinant gene technology has been used in improvements in the fields of
   a) Health b) Agriculture.

6. Build up ideas on how gene- technology can affect the future generations
   a) Biologically b) Socially c) Politically

   (Discuss both positive and negative repercussions)