

# **Microbes in Human Welfare**

# Microbes in Human Welfare

Besides macroscopic plants and animals, microbes are the **major components of biological systems** on this earth.

Microbes are present everywhere – in soil, water, air, inside our bodies and that of other animals and plants.

They are present even at sites where no other life-form could exist—such as **deep inside the geysers** (thermal vents) where the temperature may be as high as 100°C.

They are also present **deep in the soil**, under the layers of **snow** several metres thick, and in highly acidic environments.



# Microbes in Human Welfare

Microbes are diverse—**protozoa, bacteria, fungi and microscopic plants viruses, viroids** and also prions that are proteinacious infectious agents.

Bacteria and many fungi can be grown on nutrient media to form colonies, that can be seen with the naked eyes. Such cultures are useful in studies on micro-organisms.

They also cause diseases in plants and animals.

But all microbes are not harmful.

Several microbes are useful to man in diverse ways.



# **Microbes in Household Products**

# Microbes in Household Products

We use microbes or products derived from them everyday.

A common example is the conversion of milk into curd.

*Lactobacillus* and others commonly called **lactic acid bacteria (LAB)** grow in milk and convert it to curd.

During growth, the LAB produce acids that **coagulate and partially digest** the milk proteins.



# Microbes in Household Products

A small amount of curd added to the fresh milk as inoculum or starter contain millions of LAB.



They multiply at suitable temperatures, and **convert milk into curd.**

They improve its nutritional quality by **increasing vitamin B12.**

They **prevent the growth of disease causing microbes** in our stomach or gut.



# Microbes in Household Products



The dough, which is used for making *dosa* and *idli* is also fermented by bacteria.

The puffed appearance of dough is due to the formation of CO<sub>2</sub> gas.

Bacteria which ferment the dough of idli and dosa are **Leuconostoc** and **Streptococcus**.



# Microbes in Household Products



The dough, which is used for making bread, is fermented by baker's yeast.

*Saccharomyces cerevisiae*



# Microbes in Household Products



# Microbes in Household Products

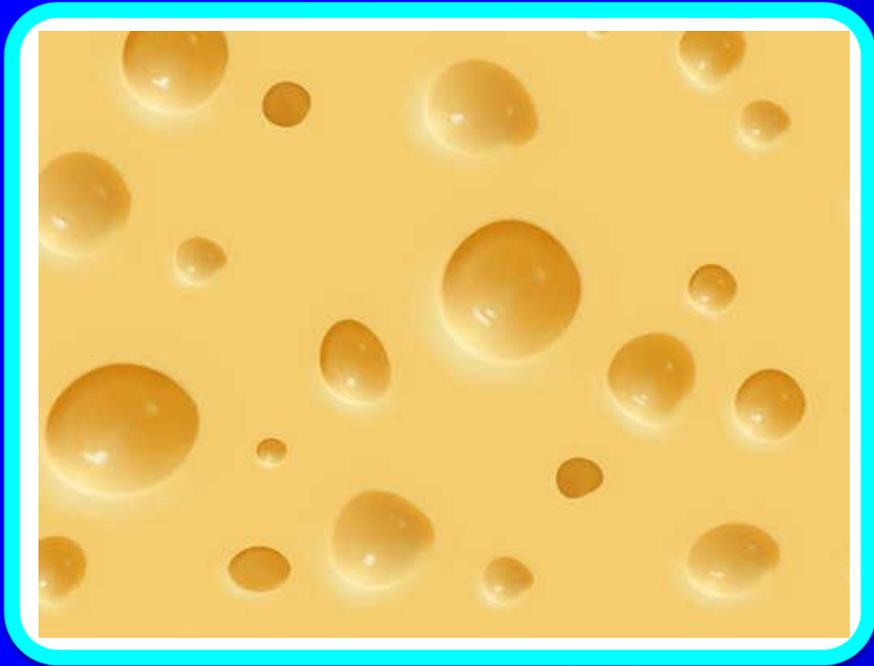
A number of traditional drinks and foods are also made by fermentation by the microbes.

**'Toddy'**, a traditional drink of some parts of southern India is made by fermenting sap from palms.

Microbes are also used to ferment **fish, soyabean and bamboo shoots** to make foods.



# Microbes in Household Products



Cheese, is one of the oldest food items in which microbes were used.

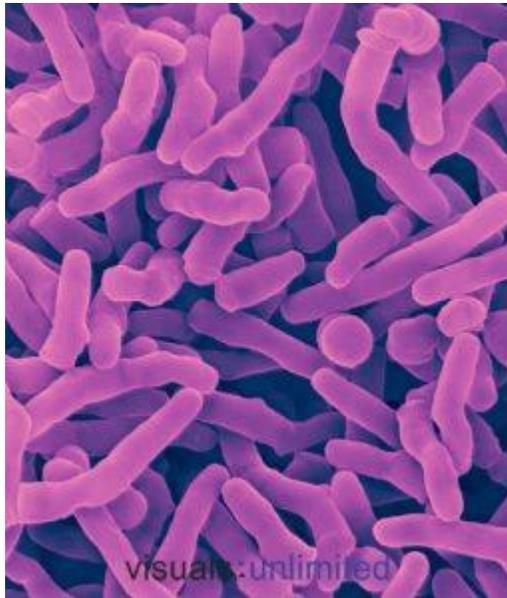
Different varieties of cheese are known by their **characteristic texture, flavour and taste**, the specificity coming from the microbes used.

The **large holes** in 'Swiss cheese' are due to production of a **large amount of CO<sub>2</sub>** by a bacterium named ***Propionibacterium sharmanii***.

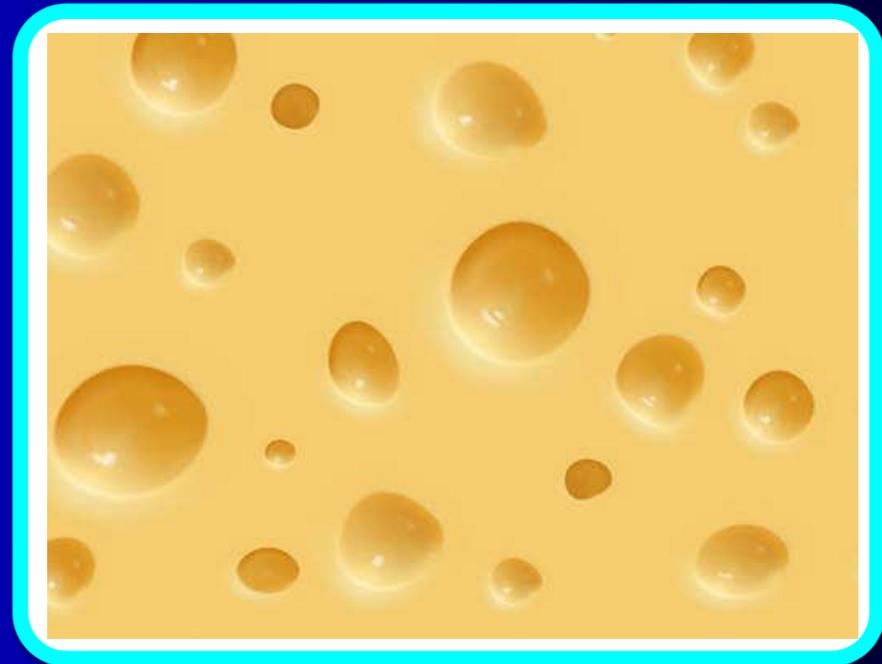


# Microbes in Household Products

*Propionibacterium sharmanii*



*Swiss Cheese*  
*(North America)*



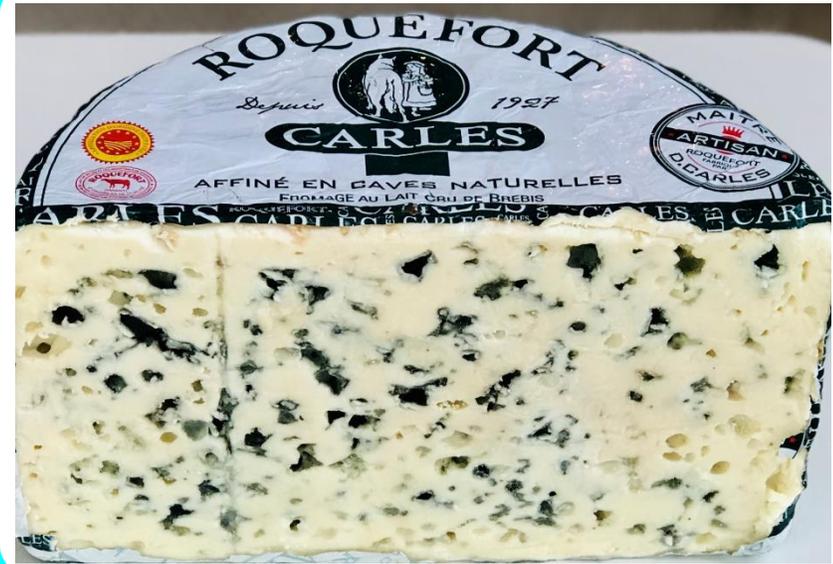
# Microbes in Household Products

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

*Penicillium roqueforti*



*Roquefort Cheese* (France) is made from sheep's milk added with *P. roqueforti*



# Microbes in Household Products

S. No	Name of microbes	Role
1	<i>Lactobacillus</i>	Converts milk into curd
2	LAB- Lactic Acid Bacteria	Converts milk into curd Increase vitamin B <sub>12</sub> in milk Check growth of pathogens in stomach
3	<i>Saccharomyces cerevisiae</i>	fermentation
4	<i>Propionibacterium</i>	Swiss cheese
5	<i>Penicillium roqueforti</i>	Roquefort cheese



# **Microbes in Industrial Products**

# Microbes in Industrial Products



Even in industry, microbes are used to synthesise a number of products valuable to human beings.

Beverages and antibiotics are made in industries, require growing microbes in very large vessels called **fermentors**



# Microbes in Industrial Products



Yeasts have been used from time immemorial for the production of beverages like wine, beer, whisky, brandy or rum.

Yeast *Saccharomyces cerevisiae* is used for bread-making.

Brewer's yeast is used for fermenting **malted cereals and fruit juices**, to produce **ethanol**.

Brewer is a person or company that manufactures beverages.



# Microbes in Industrial Products

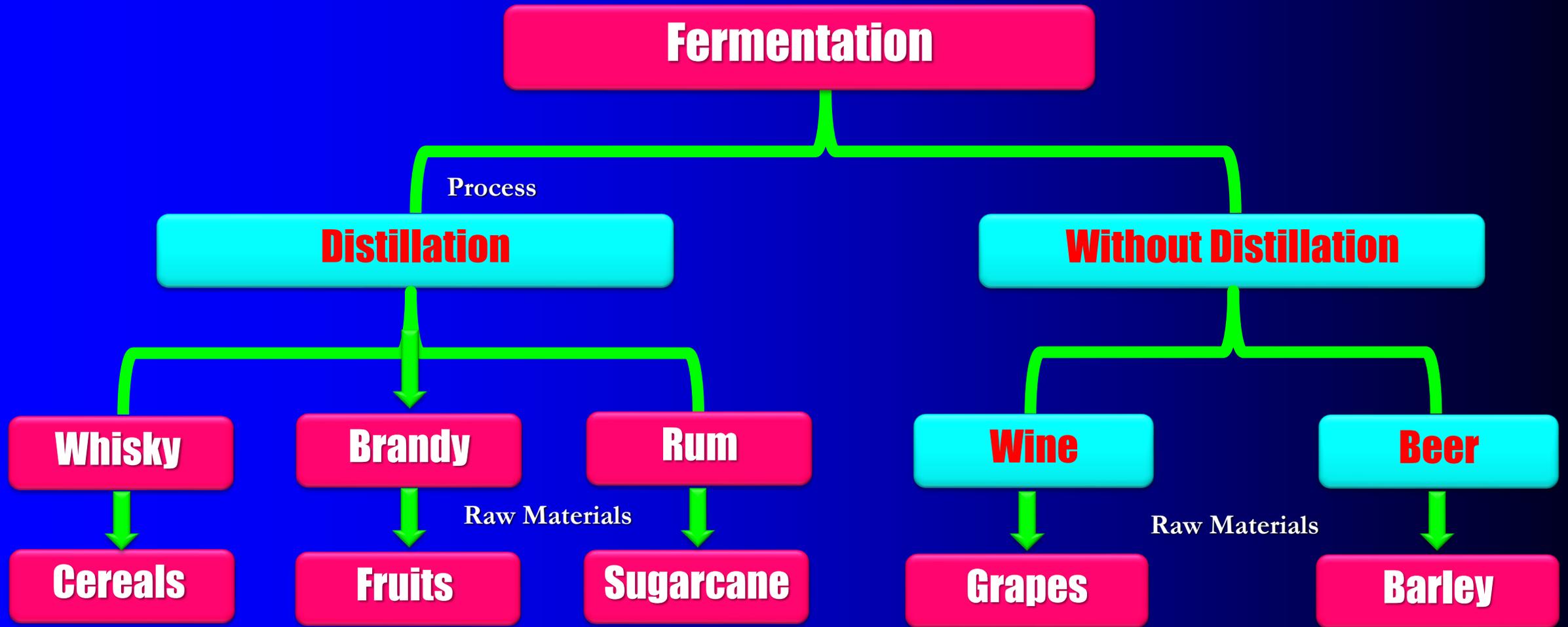


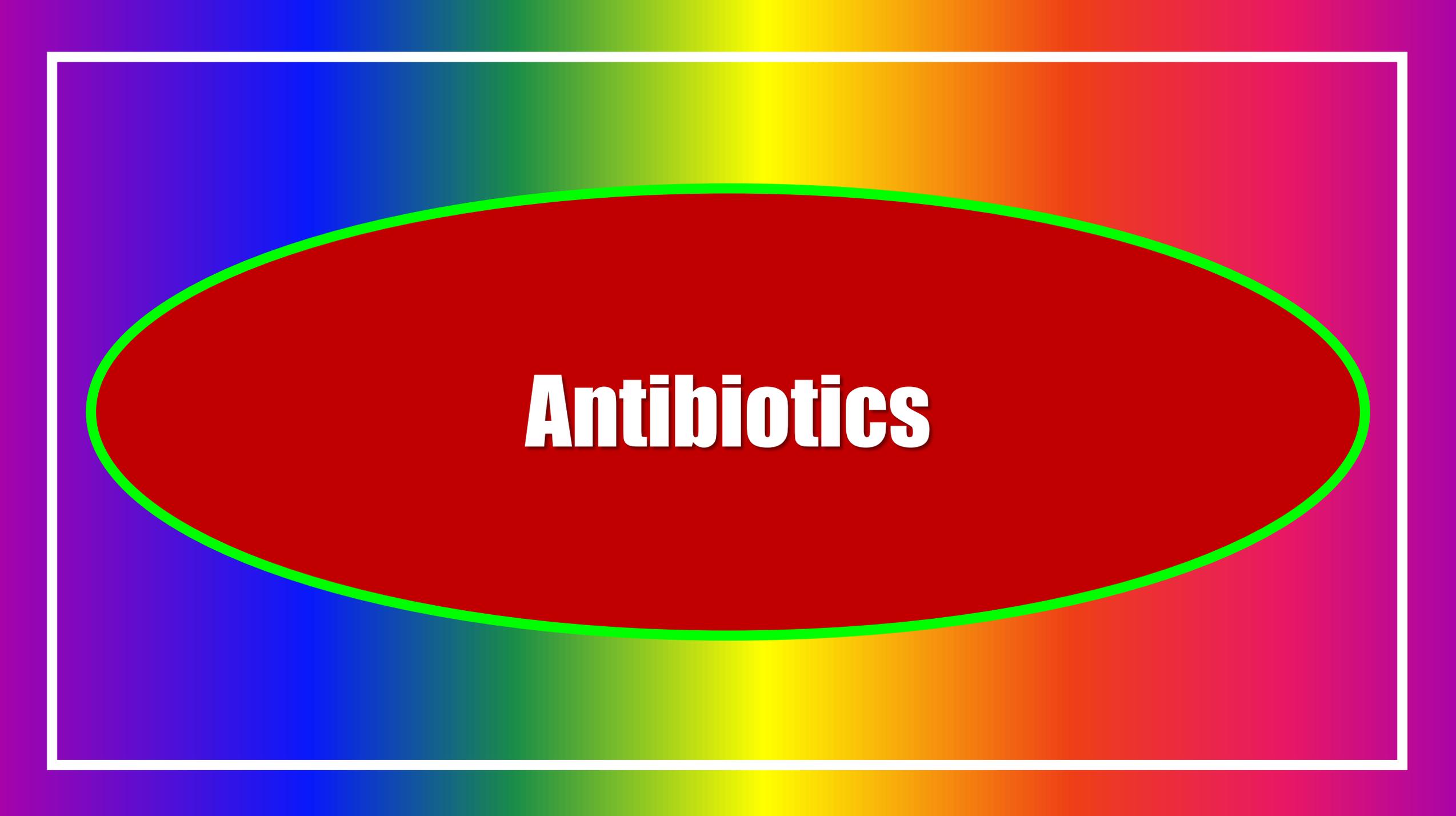
Depending on the **type of the raw material** used for fermentation and the **type of processing** (with or without distillation) different types of alcoholic drinks are obtained.

Wine and beer are produced without distillation.

Whisky, brandy and rum are produced by distillation of the fermented broth.





The image features a horizontal rainbow gradient background. A large, horizontally-oriented red oval with a bright green border is centered on the page. Inside this oval, the word "Antibiotics" is written in a bold, white, sans-serif font.

**Antibiotics**

# Antibiotics

Antibiotics produced by microbes are regarded as one of the most significant discoveries of the twentieth century and have greatly contributed towards the welfare of the human society.

*Anti* is a Greek word that means ‘against’, and *bio* means ‘life’, together they mean ‘against life’ (in the context of disease causing organisms); whereas with reference to human beings, they are ‘pro life’ and not against.

Antibiotics are chemical substances, which are produced by some microbes and can kill or retard the growth of other (disease-causing) microbes.



# Antibiotics



Penicillin was the first antibiotic to be discovered, and it was a chance discovery.

Alexander Fleming while working on *Staphylococci* bacteria, once observed a mould growing in one of his unwashed culture plates around which *Staphylococci* could not grow.

He found out that it was due to a chemical produced by the mould and he named it **Penicillin** after the mould *Penicillium notatum*.



# Antibiotics



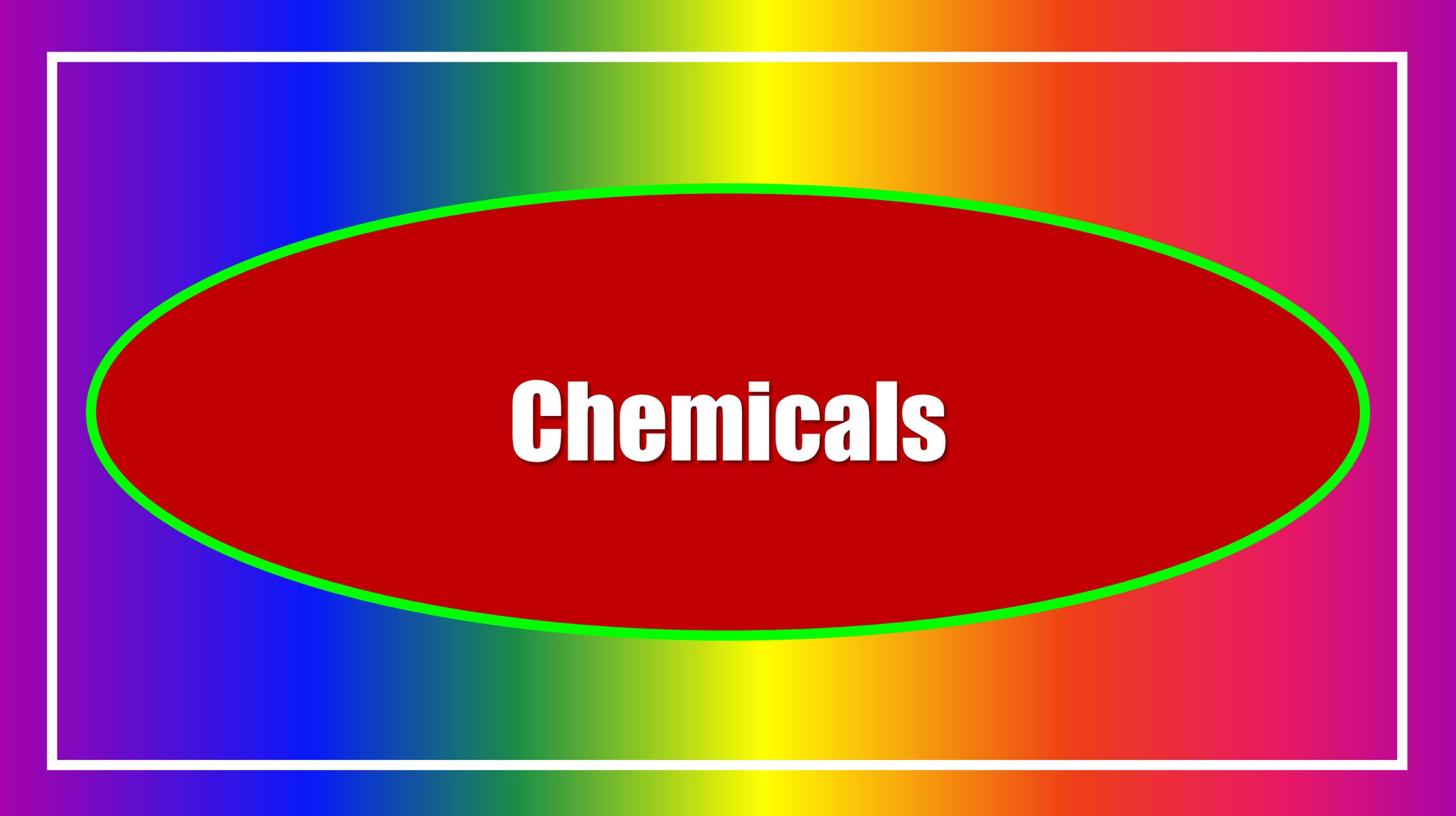
However, its full potential as an effective antibiotic was established much later by **Ernest Chain** and **Howard Florey**.

This antibiotic was used to treat American soldiers wounded in World War II.

Fleming, Chain and Florey were awarded the Nobel Prize in 1945 for this discovery.

(The Nobel Prize for Medicine in 1945 was awarded jointly to Sir Alexander Fleming, Ernst Boris Chain and Sir Howard Walter Florey "for the discovery of penicillin and its curative effect in various infectious diseases")





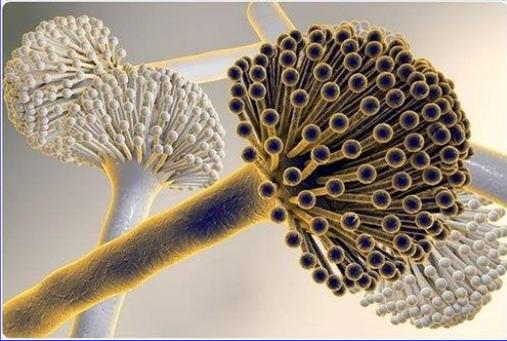
**Chemicals**

# Acid Producers

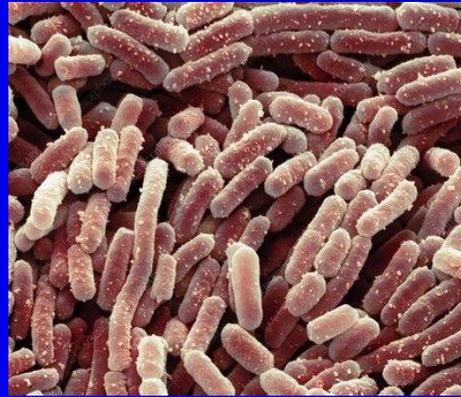
Microbes are also used for commercial and industrial production of certain chemicals like organic acids, alcohols and enzymes.



*Aspergillus niger*



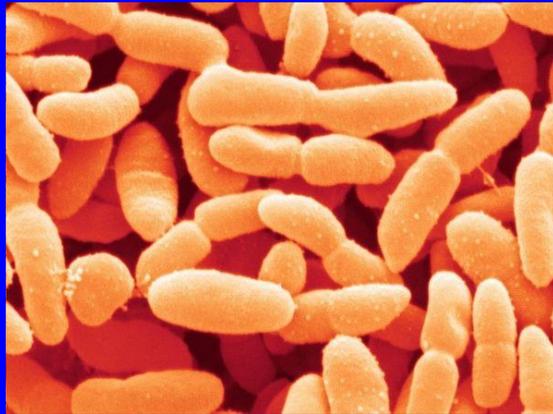
*Lactobacillus delbrueckii*



*Saccharomyces cerevisiae*

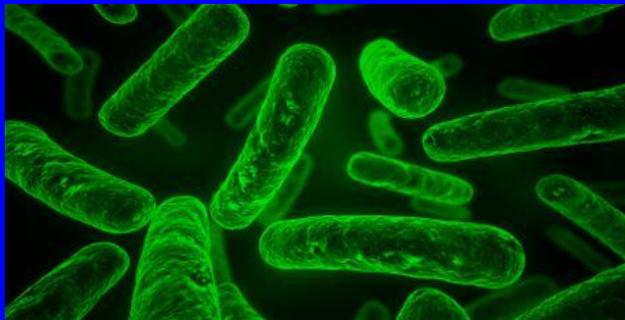


*Acetobacter aceti*



# Chemicals

*Clostridium butylicum*

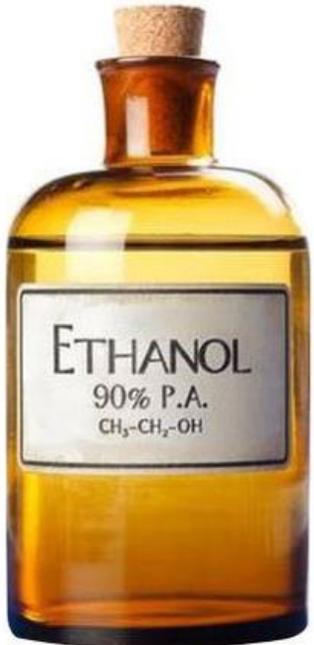


<b>Chemicals</b>	<b>Microbes</b>
Citric acid	<i>Aspergillus niger</i> (fungus)
Acetic acid	<i>Acetobacter aceti</i> (bacterium)
Butyric acid	<i>Clostridium butylicum</i> (bacterium)
Lactic acid	<i>Lactobacillus delbrueckii</i> (bacterium)
Ethanol	<i>Saccharomyces cerevisiae</i> (fungus)



# Ethanol

Ethanol



Yeast (*Saccharomyces cerevisiae*) is used for commercial production of ethanol.





**Enzymes**

# Enzymes



Microbes are also used for the production of enzymes.

**Lipases** are used in detergents to remove **oily stains** from the laundry.



# Enzymes



A Juicy Science Experiment  
Extracting  
Apple Juice  
with Pectinase



Bottled fruit juices bought from the market are clearer as compared to those made at home.

The bottled juices are clarified by the use of **pectinases and proteases**.

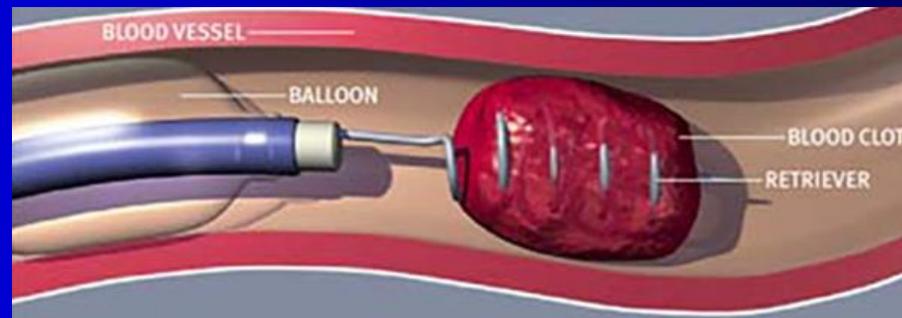


# Enzymes



**Streptokinase** is an enzyme produced by the bacterium *Streptococcus* and modified by genetic engineering.

It is used as a **'clot buster'** for removing **blood clots** from the blood vessels of patients who have undergone myocardial infarction leading to heart attack.



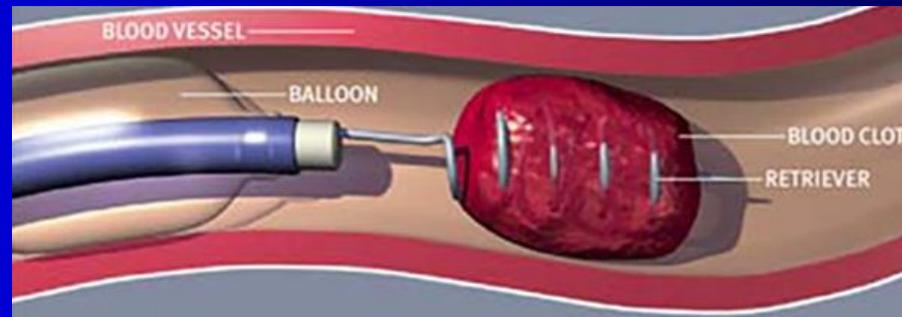
# Enzymes



Myocardial infarction means death of heart muscles (Heart Attack) due to decreased blood flow or complete stoppage of blood flow to heart.

Streptokinase is used to **dissolve blood clots** that have formed in the blood vessels.

It is used immediately after symptoms of a heart attack.



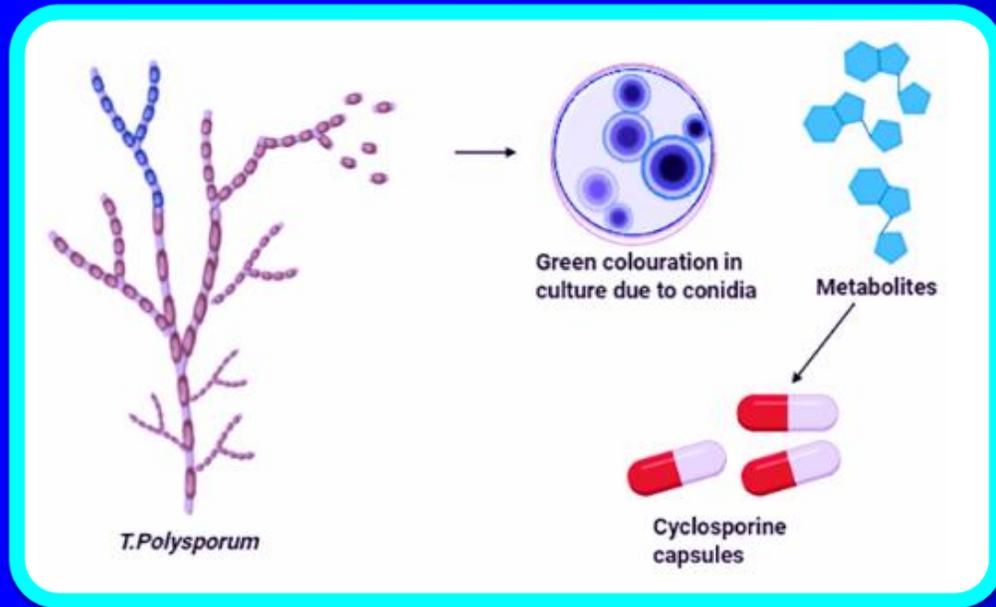
# Enzymes

S. No	Enzymes	Role
1	Lipases	Remove oily stain from laundry
2	Pectinases and Proteases	Clear fruit juices during bottling
3	Streptokinase	'Clot buster' removes blood clots



# **Bioactive Molecules**

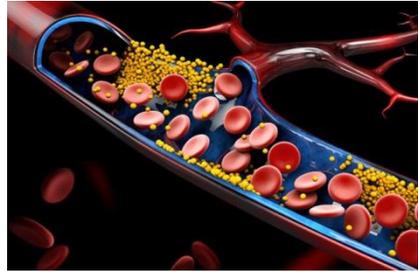
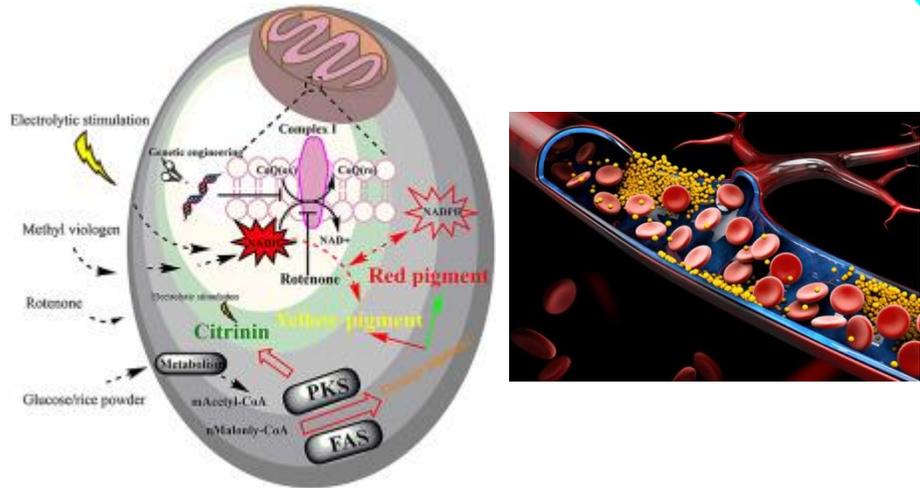
# Bioactive Molecules



The bioactive molecule, **cyclosporin A**, produced by the fungus *Trichoderma polysporum* (fungus) is used as an **immunosuppressive agent** in organ-transplant patients.



# Bioactive Molecules



**Statins** produced by the yeast *Monascus purpureus* (yeast) act as **blood-cholesterol lowering agents**.

It acts as **competitive inhibitor** of the enzyme responsible for synthesis of cholesterol.



# Bioactive Molecules

Bioactive Molecules	Microbes	Role
Cyclosporin A	<i>Trichoderma polysporum</i> (fungus)	Immuno suppressive agent
Statins	<i>Monascus purpureus</i> (yeast)	Lowers blood cholesterol levels



# Health care Molecules

Drugs	Microbes	Role
Penicillin	<i>Penicillium notatum</i> (fungus)	Antibiotic, kills the microbes
Cyclosporin A	<i>Trichoderma polysporum</i> (fungus)	Immuno suppressive agent
Statins	<i>Monascus purpureus</i> (yeast)	Lowers blood cholesterol levels
Streptokinase	<i>Streptococcus dysgalactiae</i> (bacterium)	<b>Clot buster</b> for removing <b>blood clots</b> from the blood vessels of patients of myocardial infarction.



# Health Care Products

Drugs	Microbes	Role
<b>Penicillin</b>	Penicillium notatum (fungus)	Antibiotic, kills the microbes
<b>Cyclosporin A</b>	Trichoderma polysporum (fungus)	Immuno suppressive agent
<b>Statins</b>	Monascus purpureus (yeast)	Lowers blood cholesterol levels
<b>Streptokinase</b>	Streptococcus dysgalactiae (bacterium)	Clot buster for removing blood clots from the blood vessels of patients of myocardial infarction



# **Microbes in Sewage Treatment**

# Microbes in Sewage Treatment

The municipal waste-water is also called sewage.

It contains **large amounts of organic matter and microbes.**

Many of them are pathogenic.

Before disposal, sewage is treated in Sewage Treatment Plants (STPs) to make it less polluting.

Treatment of waste water is done by the heterotrophic microbes naturally present in the sewage.

This treatment is carried out in two stages; primary and secondary treatments.



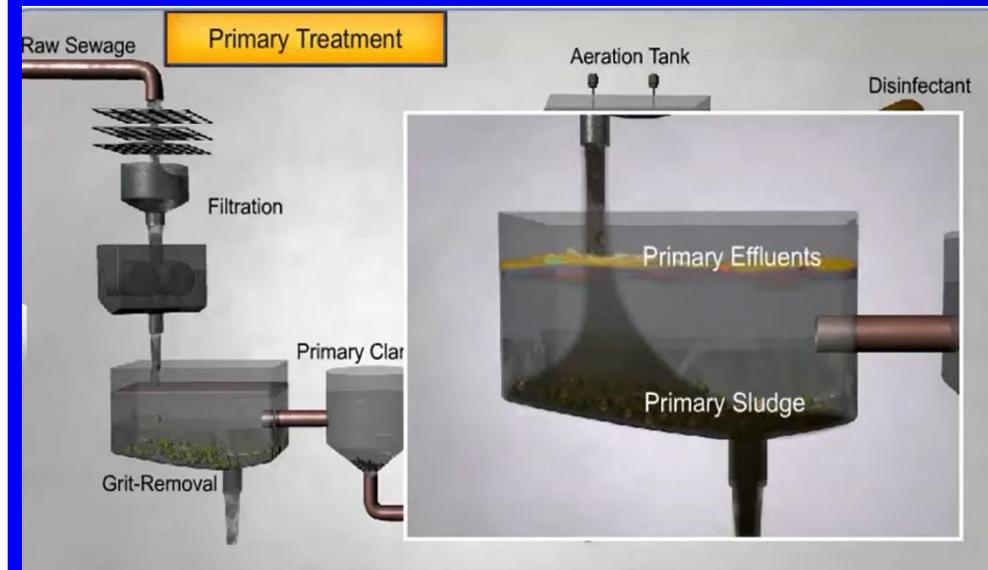
# Primary Treatment

These treatment steps basically involve **physical removal of particles** from the sewage through **filtration** and **sedimentation**.

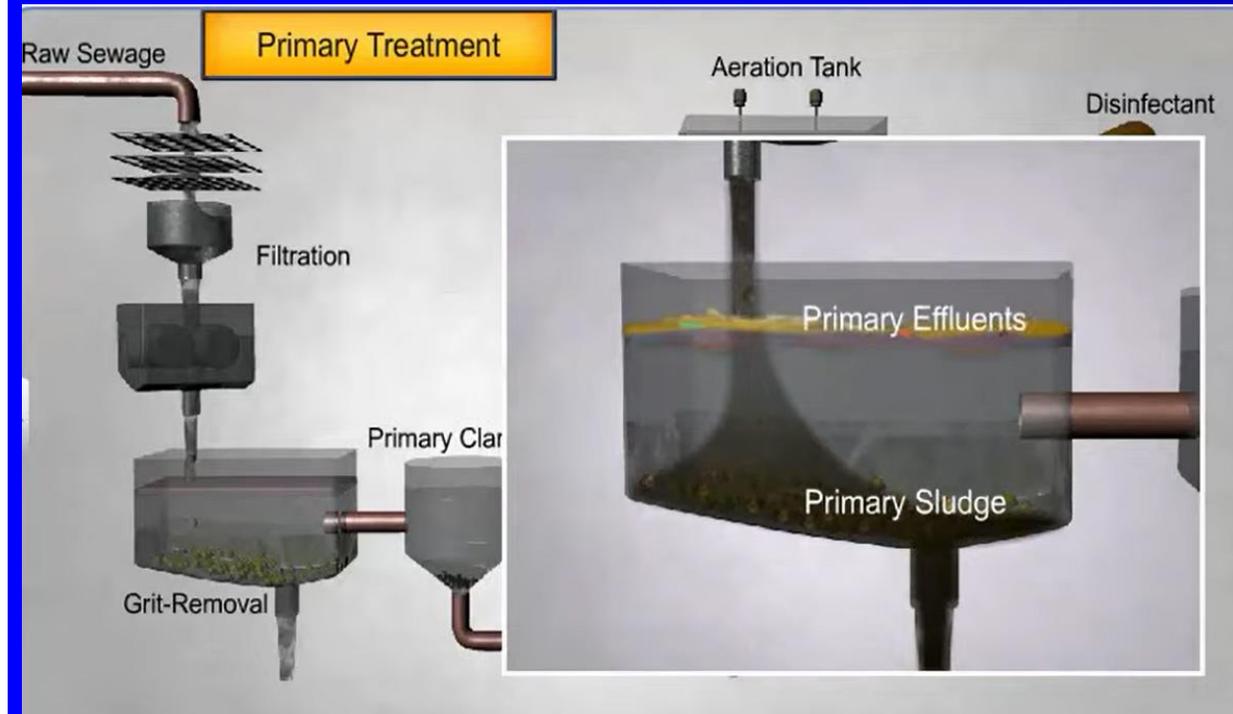
These are removed in stages;

Initially floating debris is removed by sequential filtration.

Then the grit (soil and small pebbles) are removed by sedimentation.



# Primary Treatment



The solids that settle form the **primary sludge**, and the supernatant forms the **effluent**.

The effluent from the primary settling tank is sent for secondary treatment.



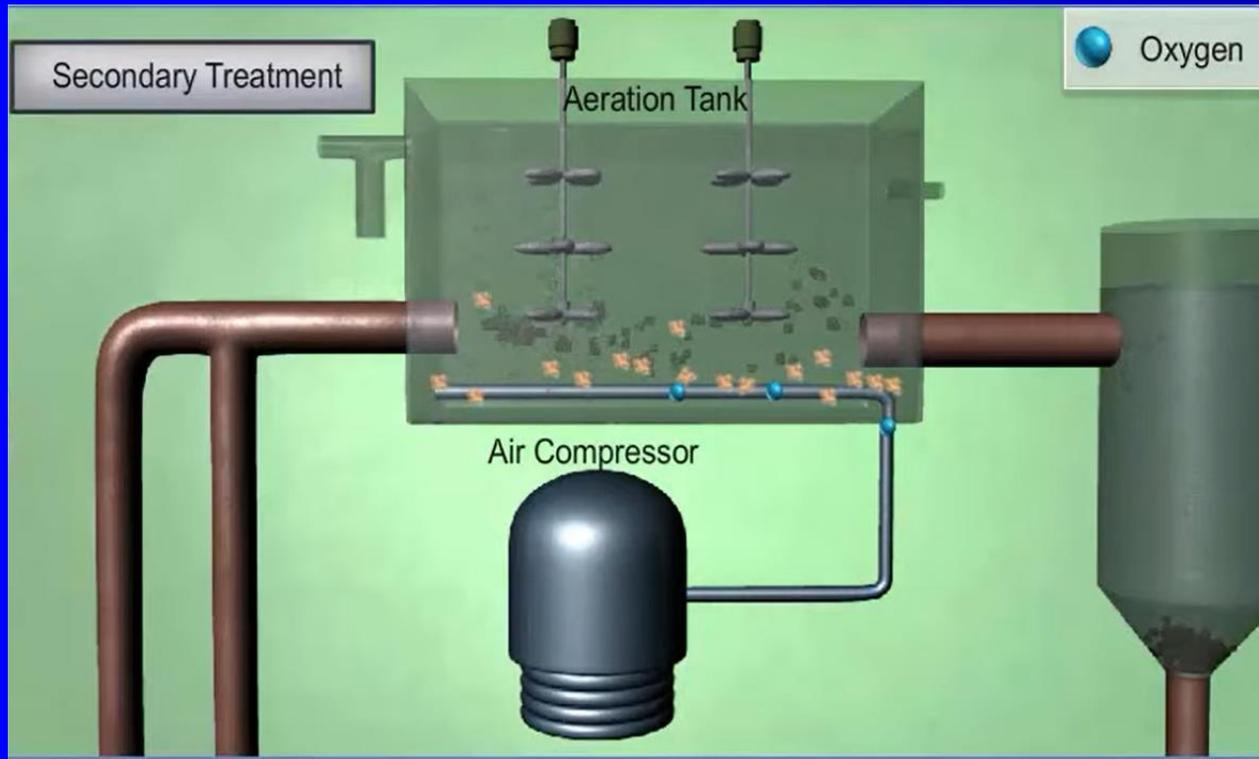
# Secondary Treatment or Biological Treatment

The primary effluent is passed into large aeration tanks.

It is **constantly agitated mechanically and air is pumped into it.**

This allows vigorous growth of useful aerobic microbes into **flocs.**

(The masses of bacteria and fungal filaments associate to form mesh like structure is called floc.)



# Secondary Treatment or Biological Treatment

Aggregation of Bacteria and Fungal Hyphae is called Floc



# Secondary Treatment or Biological Treatment

The **microbes consume major part of the organic matter** in the effluent.

This reduces the **BOD (biochemical oxygen demand)** of the effluent.

BOD refers to the amount of the oxygen required to oxidise organic matter present in one liter of water by bacteria.

The sewage water is treated till the BOD is reduced.



# Secondary Treatment or Biological Treatment

More organic matter more biological oxygen demand (BOD)

Less organic matter less biological oxygen demand (BOD)

More BOD means the pollution is high.

Less BOD means the pollution is less.



# Secondary Treatment or Biological Treatment

The BOD test measures the rate of uptake of oxygen by microorganisms in a sample of water.

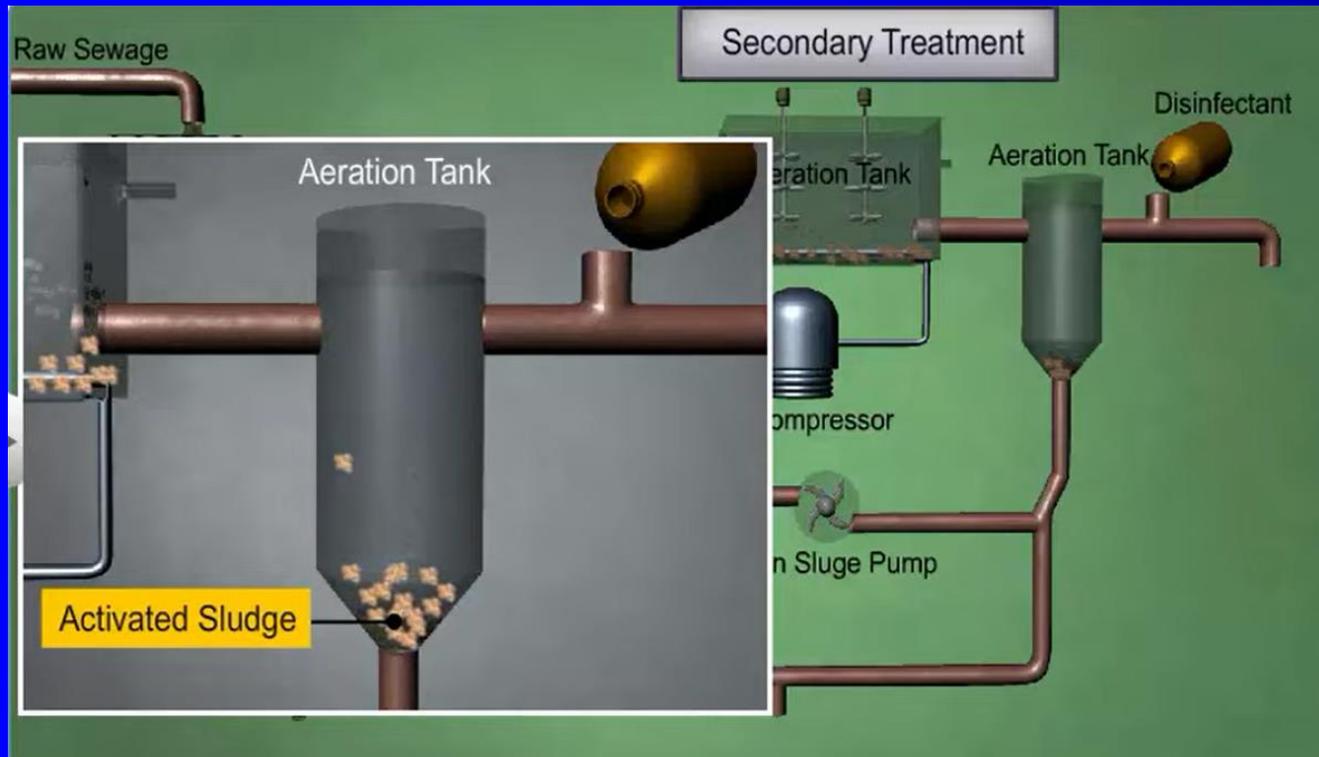
The BOD is a measure of the organic matter present in the water.

The greater the BOD of waste water, more is its polluting potential.

Once the BOD of sewage is reduced, the effluent is then passed into a settling tank where the bacterial 'flocs' are allowed to sediment.



# Secondary Treatment or Biological Treatment



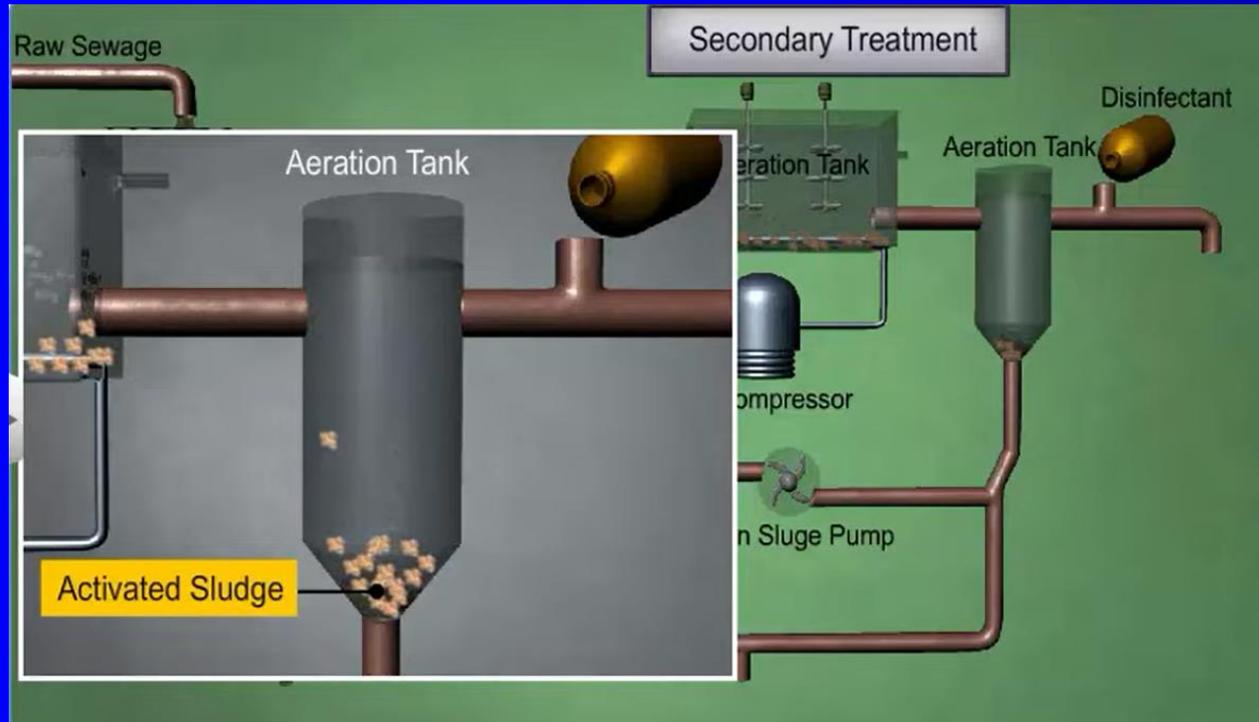
The sedimented floc is called **activated sludge**.

A small part of the activated sludge is pumped back into the aeration tank to serve as the **inoculum**.

The remaining major part of the sludge is pumped into large tanks called **anaerobic sludge digesters**.



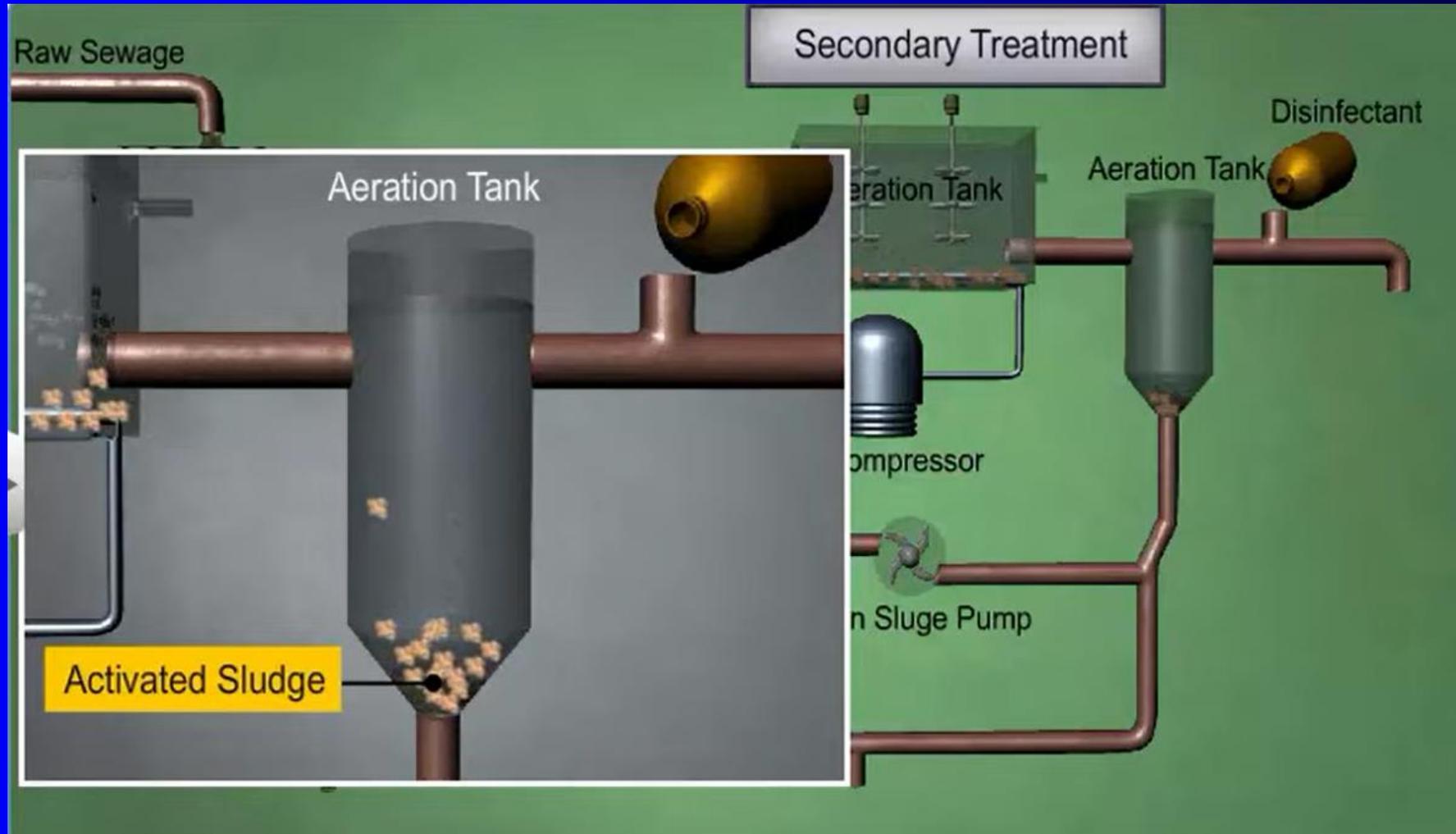
# Secondary Treatment or Biological Treatment



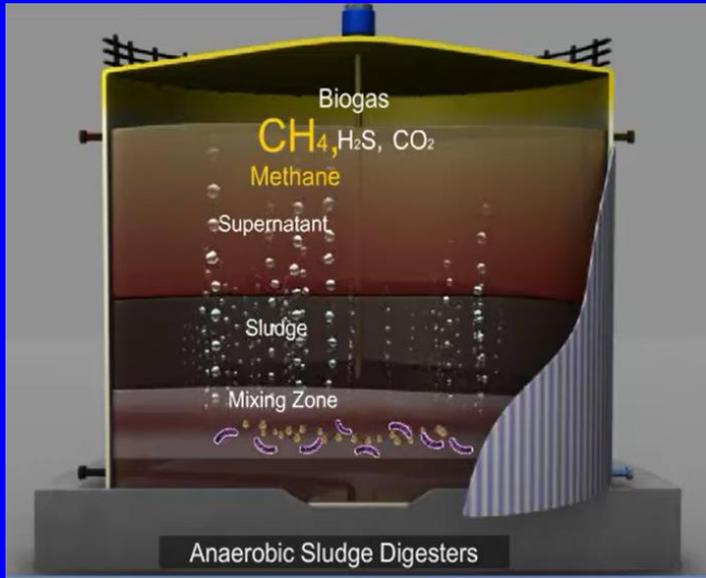
Here anaerobic bacteria which digest the aerobic bacteria and the fungi in the sludge.



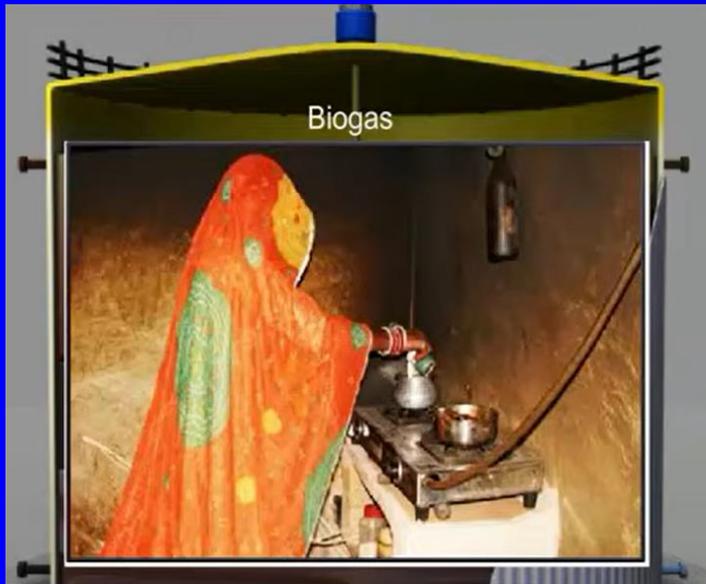
# Secondary Treatment or Biological Treatment



# Secondary Treatment or Biological Treatment



During this digestion, bacteria produce gases such as **methane, hydrogen sulphide and carbon dioxide.**



These gases form **biogas** and can be used as **source of energy as it is inflammable.**



# Secondary Treatment or Biological Treatment



The effluent from the secondary treatment plant is released into natural water bodies like rivers and streams.



# Secondary Treatment or Biological Treatment

Microbes play a major role in treating millions of gallons of waste water everyday across the globe.

This methodology has been practiced for more than a century in almost all parts of the world.



# **Microbes in Production of Biogas**

# Microbes in Production of Biogas

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

Microbes produce different types of gaseous end-products during growth and metabolism.

The type of the gas produced depends upon the **microbes and the organic substrates** they utilise.

Certain bacteria, which grow anaerobically on cellulosic material, produce large amount of **Methane along with CO<sub>2</sub> and H<sub>2</sub>.**



# Microbes in Production of Biogas

The bacteria which produce biogas are collectively called **methanogens**, and one such common bacterium is *Methanobacterium*.

These bacteria are commonly found in the **anaerobic sludge** during sewage treatment.

These bacteria are also present in the rumen (a part of stomach) of cattle.

A lot of cellulosic material present in the food of cattle is also present in the rumen.



# Microbes in Production of Biogas

In rumen, these bacteria help in the breakdown of cellulose and play an important role in the nutrition of cattle.

Thus, the excreta (dung) of cattle, commonly called *gobar*, is rich in these bacteria.

Cow dung is used for the production of biogas, commonly called *gobar gas*.



# Microbes in Production of Biogas

Cattle dung is available in large quantities in rural areas where cattle are used for a variety of purposes.

So biogas plants are more in rural areas.

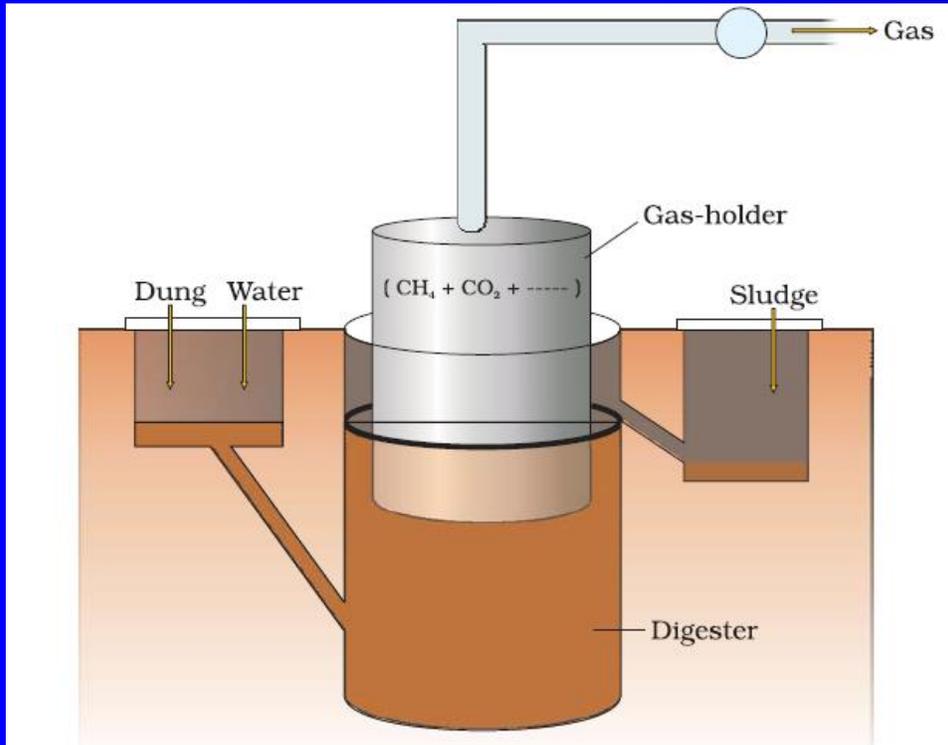
The biogas produced is used for cooking and lighting.

The technology of biogas production was developed in India mainly due to the efforts of

**Indian Agricultural Research Institute (IARI) and  
Khadi and Village Industries Commission (KVIC).**



# Structure of a Biogas Plant



The biogas plant consists of a concrete tank (10-15 feet deep) in which bio-wastes are collected and a slurry of dung is fed.

A floating cover is placed over the slurry, which keeps on rising as the gas is produced in the tank due to the microbial activity.

The biogas plant has an outlet, which is connected to a pipe to supply biogas to nearby houses.

The spent slurry is removed through another outlet and may be used as fertiliser.

The biogas thus produced is used for cooking and lighting.



# Composition of Biogas

Composition	Volume
Methane (CH <sub>3</sub> )	50-75 %
Carbon dioxide (CO <sub>2</sub> )	25-50%
Nitrogen (N <sub>2</sub> )	2-8%
Hydrogen sulphide (H <sub>2</sub> S)	0-2%
Hydrogen (H <sub>2</sub> )	0-1%

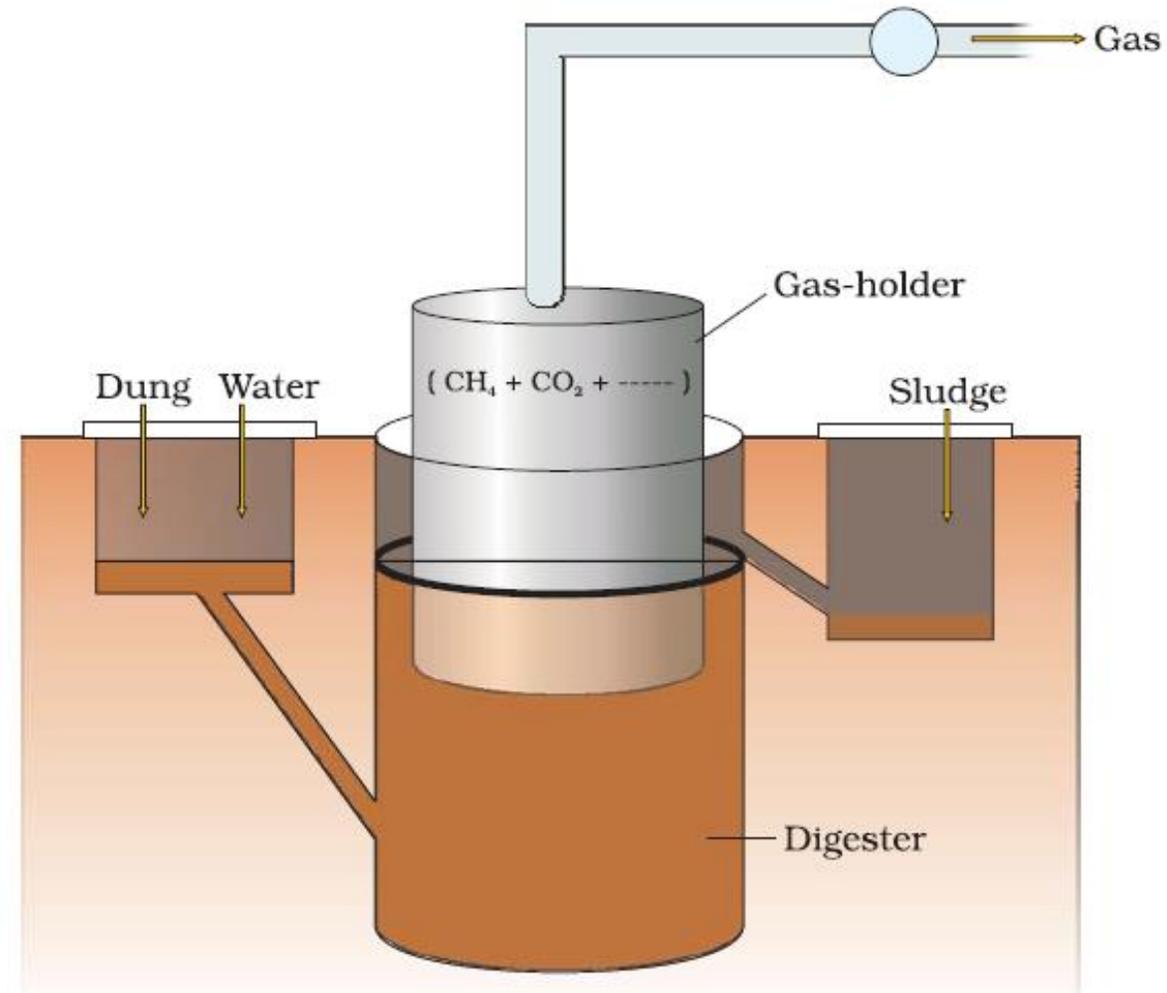


Ministry of Environment and Forests has initiated **Ganga Action Plan** and **Yamuna Action Plan** to save these major rivers of our country from pollution.

Under these plans, it is proposed to build a large number of sewage treatment plants so that only treated sewage may be discharged in the rivers.



# Structure of a Biogas Plant



# **Microbes as Biocontrol Agents**

# Microbes as Biocontrol Agents

Biocontrol refers to the use of biological methods for controlling plant diseases and pests.

The chemical pesticides are toxic and extremely harmful, to human beings and animals and have been polluting our environment (soil, ground water), fruits, vegetables and crop plants.

Our soil is also polluted through the use of weedicides to remove weeds.

The use of biocontrol measures will greatly reduce our dependence on toxic chemicals and pesticides.



# Microbes as Biocontrol Agents

The very familiar beetle with red and black markings

Ladybird, and Dragonflies are useful to get rid of aphids and mosquitoes, respectively.



# Microbes as Biocontrol Agents

An example of microbial biocontrol agents that can be introduced in order to control **butterfly caterpillars** is the bacteria *Bacillus thuringiensis* (often written as *Bt* ).

These are available in sachets as dried spores which are mixed with water and sprayed onto vulnerable plants such as **brassicas and fruit trees**, where these are eaten by the insect larvae.

In the gut of the larvae, the toxin is released and the larvae get killed.

The toxin kills the caterpillars, but leave other insects unharmed.



# Microbes as Biocontrol Agents

*Trichoderma* species are free-living fungi that are very common in the root ecosystems.

They are effective biocontrol agents of several plant pathogens.

Baculoviruses are pathogens that attack insects and other arthropods.

The majority of baculoviruses used as biological control agents are in the genus *Nucleopolyhedrovirus*.



# Microbes as Biocontrol Agents

These viruses are excellent candidates for species-specific, narrow spectrum insecticidal applications.

They have been shown to have no negative impacts on plants, mammals, birds, fish or even on non-target insects.

This is especially desirable when beneficial insects are being conserved to aid in an overall integrated pest management (IPM) programme, or when an ecologically sensitive area is being treated.



# Biological Pest Control

No	Organisms	Pathogens
1	Lady birds	Aphids
2	Dragonflies	Mosquitoes
3	Bacillus thuringiensis	Caterpillars of butterfly
4	Trichoderma	Plant Pathogens
5	Baculoviruses	Insects



# **Microbes as Biofertilizers**

# Microbes as Biofertilizers

The main sources of biofertilisers are **bacteria, fungi and cyanobacteria**.

The symbiotic bacteria *Rhizobium* fixes atmospheric nitrogen into organic forms, which is used by the plant as nutrient.

The free-living bacteria *Azospirillum* and *Azotobacter* can fix atmospheric nitrogen thus enriching the nitrogen content of the soil.



# Microbes as Biofertilizers

Fungi are also known to form symbiotic associations with plants (**mycorrhiza**). Many members of the genus *Glomus* form mycorrhiza.

The fungal symbiont in these associations absorbs 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.



# Microbes as Biofertilizers

Cyanobacteria are autotrophic microbes widely distributed in aquatic and terrestrial environments many of which can fix atmospheric nitrogen, e.g. *Anabaena*, *Nostoc*, *Oscillatoria*, etc.

In paddy fields, cyanobacteria serve as an important biofertiliser.

Blue green algae also add organic matter to the soil and increase its fertility.

A number of biofertilisers are available commercially in the market and farmers use these regularly in their fields to replenish soil nutrients and to reduce dependence on chemical fertilisers.



# Microbes as Biofertilizers

No	Name of Organism	Type	Function
1	Rhizobium	Symbiotic bacteria	Fixes atmospheric Nitrogen
2	Azospirillum and Azotobacter	Free Living Bacteria	Fix atmospheric Nitrogen
3	Anabaena, Nostoc, Oscillatoria	Cyanobacteria or Blue green algae	Fix atmospheric Nitrogen. Add organic matter to the soil and increase its fertility.



# Microbes as Biofertilizers

No	Name of Organism	Type	Function
4	Mycorrhizae	Symbiotic Fungi	Absorbs phosphorus from soil and passes it to the plant. Provides resistance to root-borne pathogens, Tolerance to salinity and drought, Overall increase in plant growth and development.





**God Bless You!**