# Ch 8 · Microbes in Human Welfare

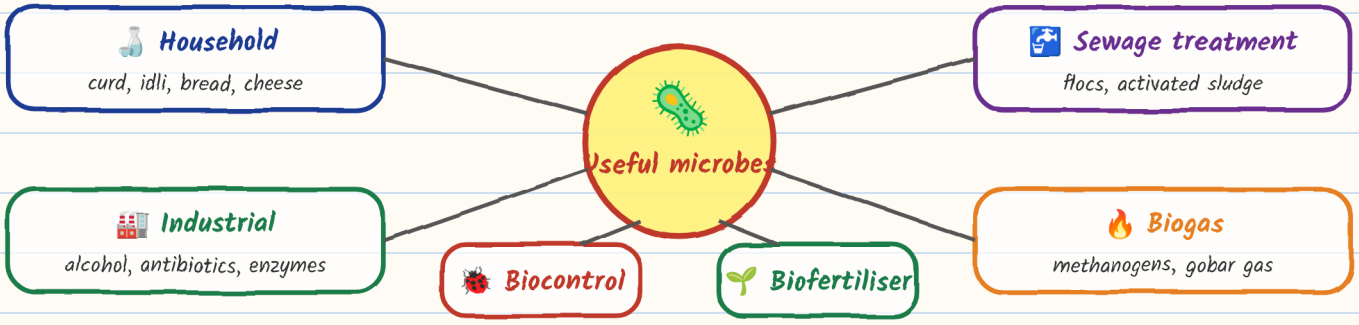
## अध्याय 8 · मानव कल्याण में सूक्ष्मजीव

Class 12 Biology · NCERT based · English + हिंदी · ✍️ revision notes

**Index / विषय-सूची**


1. Introduction to microbes
2. Microbes in household products
3. Microbes in industrial products
4. Microbes in sewage treatment
5. Microbes in production of biogas
6. Microbes as biocontrol agents
7. Microbes as biofertilisers
8. ⭐ Exam Corner (Q&A)


**Microbes help us in 6 ways · सूक्ष्मजीवों के 6 उपयोग**



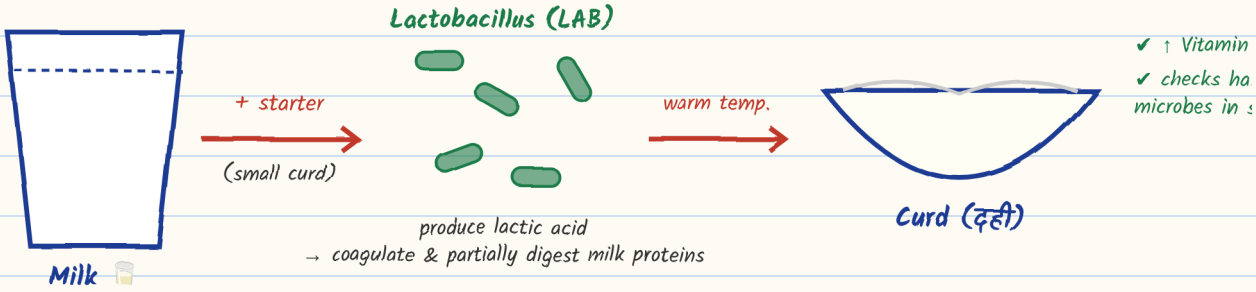

Infographic: chapter map

## Introduction / परिचय

- **Microbes** (सूक्ष्मजीव) are present **everywhere** – soil, water, air, inside our bodies & those of other animals and plants.
- Found even where no other life form could exist: deep inside **geysers** (thermal vents) where temperature may be as high as **100 °C**, deep in soil, under layers of snow several metres thick, and in highly **acidic** environments.
- Diverse: **protozoa, bacteria, fungi**, microscopic animal & plant viruses, **viroids** and also **prions** (proteinaceous infectious agents).
- Bacteria & many fungi can be grown on **nutritive media** to form **colonies** – visible to naked eye; useful in studies on micro-organisms.

- Many microbes cause diseases, but **several microbes are useful to man** in diverse ways.

# I. Microbes in Household Products / घरेलू उत्पादों में सूक्ष्मजीव




Infographic: Milk to curd by lactic acid bacteria · दूध से दही

- **Curd**: *Lactobacillus* & others commonly called **lactic acid bacteria (LAB)** grow in milk & convert it to curd.
- LAB produce **acids** that **coagulate & partially digest milk proteins**.
- A small amount of curd added to fresh milk as **inoculum or starter** contains millions of LAB, which at suitable temperature multiply → convert milk to curd.
- LAB also improve nutritional quality by increasing vitamin $B_{12}$.
- In our **stomach**, LAB play a very beneficial role in **checking disease-causing microbes**.
- **Dough** for **dosa & idli** is fermented by **bacteria**. Puffed-up appearance is due to production of **$CO_2$** gas.
- **Bread** dough is fermented using baker's yeast (*Saccharomyces cerevisiae*).
- **Toddy** – traditional drink of some parts of **southern India**, made by fermenting **sap from palms**.
- Microbes are also used to ferment **fish, soyabean & bamboo shoots** to make foods.

## Cheese पनीर / चीज़

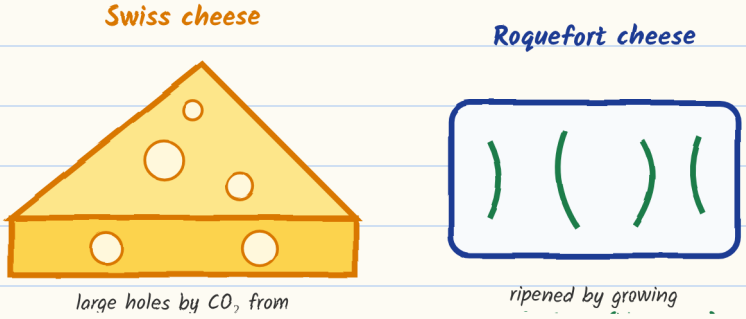



Fig: Cheese made using microbes

- One of the oldest food items in which microbes were used. Different varieties of cheese known by characteristic **texture, flavour & taste** – specificity comes from the microbes used.

- **Swiss cheese**: large holes due to production of large amount of $CO_2$ by bacterium *Propionibacterium sharmanii*.
- **Roquefort cheese**: ripened by growing **specific fungi** on them, giving a particular flavour.

## 2. Microbes in Industrial Products / औद्योगिक उत्पादों में सूक्ष्मजीव

Production on an industrial scale requires growing microbes in **very large vessels** called *fermentors* (किण्वक).

### (a) Fermented beverages किण्वित पेय

- Yeast *Saccharomyces cerevisiae* (commonly called **brewer's yeast**) used for fermenting **malted cereals & fruit juices** to produce **ethanol**.
- Depending on raw material & type of processing (with or without distillation), different alcoholic drinks are obtained.

| Without distillation | With distillation (आसवन) |
|---|---|
| Wine & beer | Whisky, brandy & rum |

📌 **Same yeast, two names:** *Saccharomyces cerevisiae* = **baker's yeast** (bread) = **brewer's yeast** (beverages) → also used for commercial production of **ethanol**.

### (b) Antibiotics प्रतिजैविक

- 'Anti' = against, 'bio' = life → chemical substances produced by some microbes that can **kill or retard growth of other (disease-causing) microbes**.
- One of the most significant discoveries of the 20th century; greatly contributed to human welfare.

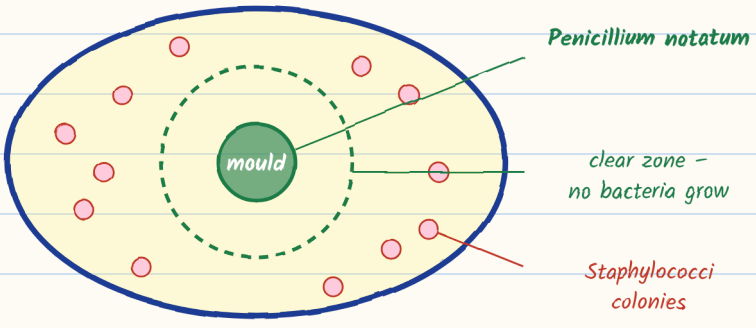



Fig: Fleming's observation – mould inhibits bacteria · ~~फ्लेमिंग का अवलोकन~~

- **Penicillin** – the first antibiotic discovered, a chance discovery by *Alexander Fleming*.
- While working on ***Staphylococci*** bacteria, he observed a mould growing in one of his unwashed culture plates around which *Staphylococci* could not grow. Found it was due to a chemical

produced by mould → named it **Penicillin** after the mould *Penicillium notatum*.

- Its full potential as an effective antibiotic was established much later by **Ernest Chain & Howard Florey**. Used to treat wounded American soldiers in **World War II**.
- **Fleming, Chain & Florey** awarded the *Nobel Prize in 1945*.
- Antibiotics have greatly improved our capacity to treat deadly diseases: **plague, whooping cough (kali khansi), diphtheria (gal ghotu) & leprosy (kusht rog)**.

## (c) Chemicals, enzymes & other bioactive molecules रसायन, एंजाइम व अन्य जैवसक्रिय अणु

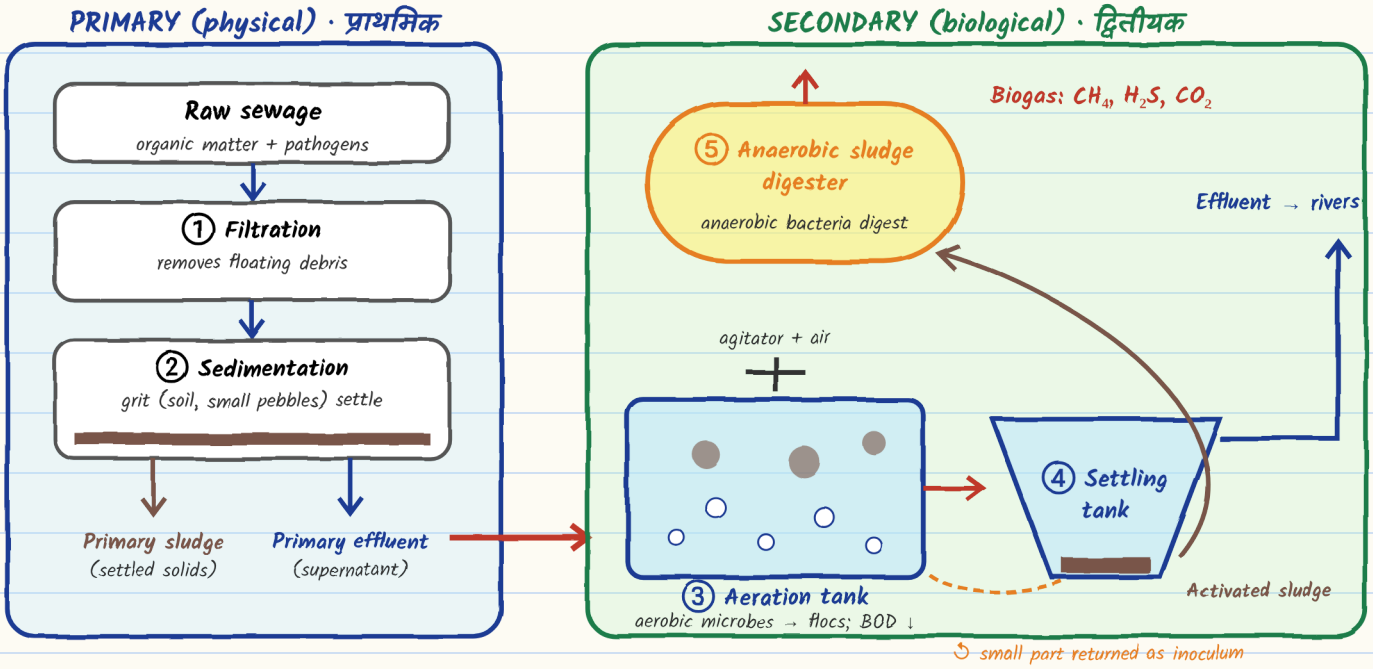
| Microbe | Type | Product |
|---|---|---|
| *Aspergillus niger* | Fungus | Citric acid (सिट्रिक अम्ल) |
| *Acetobacter aceti* | Bacterium | Acetic acid (एसिटिक अम्ल) |
| *Clostridium butylicum* | Bacterium | Butyric acid (ब्यूटिरिक अम्ल) |
| *Lactobacillus* | Bacterium | Lactic acid (लैक्टिक अम्ल) |
| *Saccharomyces cerevisiae* | Yeast | Ethanol (एथेनॉल) |

📌 **Trick:** **A**spergillus → **C**itric ("A Citrus") · **Ace**tobacter → **Ace**tic · **C**lostridium **but**ylicum → **But**yric · **Lact**obacillus → **Lact**ic. The names give the answer!

| Enzyme / Bioactive molecule | Source | Use |
|---|---|---|
| **Lipases** | Microbes | In **detergent** formulations – remove **oily stains** from laundry |
| **Pectinases & Proteases** | Microbes | **Clarify** bottled fruit juices (bottled juices are clearer than home-made) |
| **Streptokinase** | Bacterium *Streptococcus*, modified by genetic engineering | 'Clot buster' – removes clots from blood vessels of patients with **myocardial infarction** (heart attack) |
| **Cyclosporin A** | Fungus *Trichoderma polysporum* | **Immunosuppressive agent** in **organ-transplant** patients |
| **Statins** | Yeast *Monascus purpureus* | **Blood-cholesterol lowering** agents – act by **competitively inhibiting** the enzyme responsible for cholesterol synthesis |

# 3. Microbes in Sewage Treatment / वाहित मल उपचार में सूक्ष्मजीव

- Large quantities of waste water generated daily in cities & towns. Major component = **human excreta**. This municipal waste-water = sewage (वाहित मल).
- Contains large amounts of **organic matter** & microbes, many of which are **pathogenic** → cannot be discharged directly into rivers/streams.
- Before disposal, sewage is treated in sewage treatment plants (STPs) to make it less polluting. Treatment done by **heterotrophic microbes** naturally present in sewage.
- Carried out in **two stages**: primary & secondary.




Infographic: Sewage treatment plant – primary & secondary treatment · वाहित मल उपचार संयंत्र

## (a) Primary treatment प्राथमिक उपचार – physical

- Physical removal of particles – large & small – from sewage through **filtration & sedimentation**, done in stages.
- Floating debris removed by **sequential filtration**. Grit (soil & small pebbles) removed by **sedimentation**.
- All solids that settle = primary sludge; supernatant = effluent.
- Effluent from primary settling tank is taken for secondary treatment.

## (b) Secondary / Biological treatment द्वितीयक / जैविक उपचार

1. Primary effluent passed into large aeration tanks, constantly **agitated mechanically** and **air pumped** into it.
2. Allows vigorous growth of useful **aerobic microbes** into flocs (ऊर्णक) = masses of **bacteria associated with fungal filaments** to form mesh-like structures.
3. While growing, these microbes consume the major part of organic matter in effluent → significantly reduces BOD.
4. Once BOD of sewage reduced significantly, effluent passed into a **settling tank** where bacterial flocs sediment = activated sludge (सक्रियित आपंक).

5. Small part of activated sludge pumped back into aeration tank to serve as **inoculum**.
6. Remaining major part pumped into large tanks called anaerobic sludge digesters. Here other kinds of bacteria, which grow **anaerobically**, digest the bacteria & fungi in sludge → produce gases like **methane, hydrogen sulphide & $CO_2$ = biogas** (inflammable → source of energy).
7. Effluent from secondary treatment plant is generally released into natural water bodies like rivers & streams.

**BOD – Biochemical Oxygen Demand** (जैव रासायनिक ऑक्सीजन माँग):

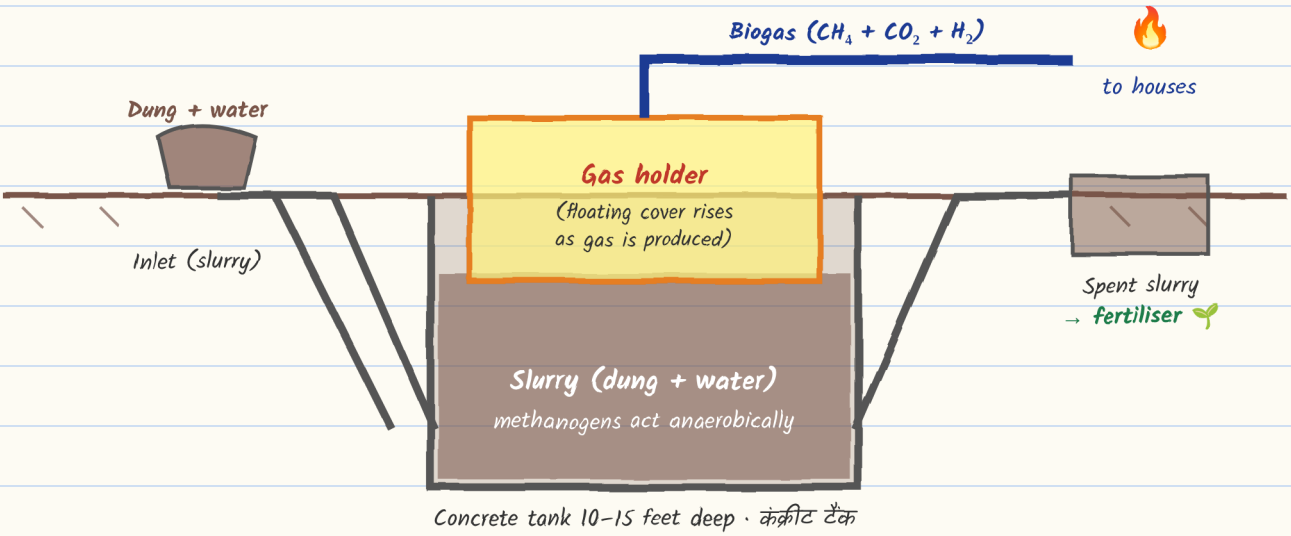
Amount of oxygen that would be consumed if all the **organic matter in one litre of water** were oxidised by bacteria.

- Sewage water treated till BOD is reduced.
- BOD test measures rate of uptake of oxygen by micro-organisms in a sample → indirectly a **measure of organic matter** in water.
- Greater the BOD → more is its polluting potential.

📌 **Government initiatives:** Due to increasing urbanisation, sewage production increased but STPs didn't increase → untreated sewage discharged into rivers → pollution & water-borne diseases. **Ministry of Environment & Forests** initiated Ganga Action Plan & Yamuna Action Plan to save these major rivers from pollution – large number of STPs to be built so that only treated sewage is discharged.

## 4. Microbes in Production of Biogas / बायोगैस उत्पादन में सूक्ष्मजीव

- **Biogas** = mixture of gases (containing **predominantly methane**) produced by microbial activity; can be used as **fuel**.
- Certain bacteria which grow **anaerobically on cellulosic material** produce large amount of methane along with $CO_2$ & $H_2$. Collectively called methanogens (मीथेनोजेन); one such common bacterium is *Methanobacterium*.
- Methanogens commonly found in **anaerobic sludge** during sewage treatment.
- Also present in the **rumen** (part of stomach) of cattle. A lot of cellulosic material in cattle food is present in rumen; there these bacteria help in **breakdown of cellulose** & play an important role in nutrition of cattle.
- Thus the excreta (**dung**) of cattle, commonly called **gobar**, is rich in these bacteria. Dung can be used to generate biogas = gobar gas.



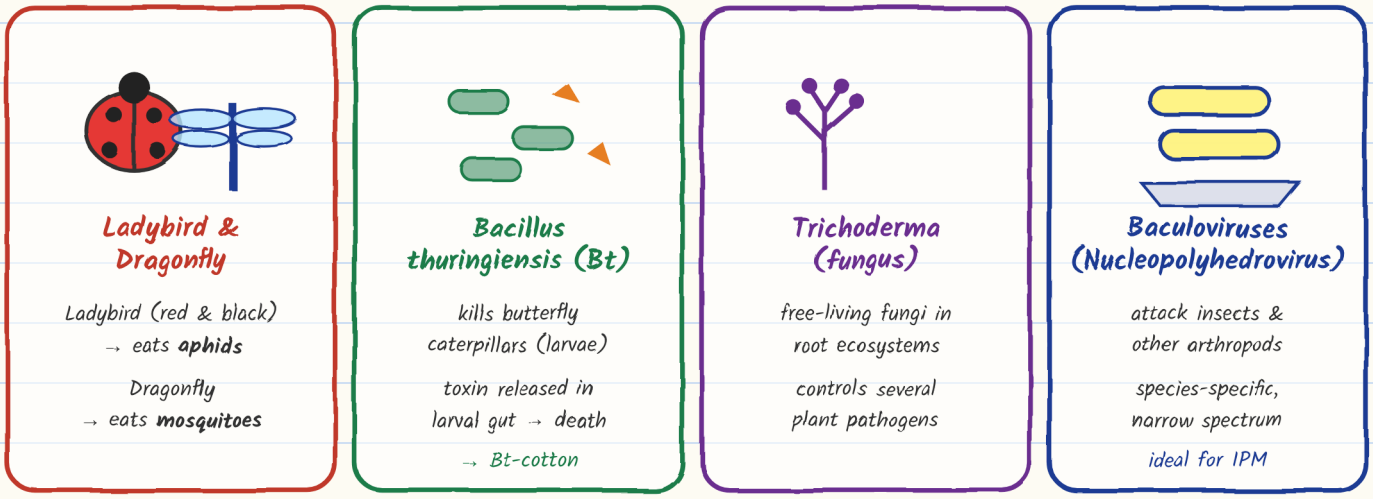

*Infographic: A typical biogas (gobar gas) plant · बायोगैस संयंत्र*

- Biogas plant consists of a **concrete tank (10–15 feet deep)** in which bio-wastes are collected & a slurry of dung is fed.
- A **floating cover** is placed over the slurry, which keeps on **rising as gas is produced** in the tank due to microbial activity.
- Biogas plant has an **outlet** connected to a pipe to supply biogas to nearby houses. **Spent slurry** removed through another outlet → used as **fertiliser**.
- Cattle dung available in large quantities in rural areas → biogas plants more often built in rural areas. Biogas used for **cooking & lighting**.
- Technology of biogas production developed in India mainly due to efforts of IARI (Indian Agricultural Research Institute) & KVIC (Khadi and Village Industries Commission).

## 5. Microbes as Biocontrol Agents / जैव नियंत्रण कारक के रूप में सूक्ष्मजीव

- **Biocontrol** (जैव नियंत्रण) = use of **biological methods** for controlling plant diseases & pests.
- Chemicals (insecticides, pesticides) used in modern society are **toxic & extremely harmful** to human beings & animals, and pollute environment (soil, ground water), fruits, vegetables & crop plants. Weedicides also pollute soil.
- **Organic farmer**: holds that **biodiversity furthers health**. The more variety a landscape has, the more sustainable it is. Creates a system where insects that are sometimes called pests are **not eradicated**, but kept at **manageable levels** by a complex system of **checks & balances** within a living & vibrant ecosystem.
- Eradication of 'pests' is undesirable – without them the beneficial predatory & parasitic insects which depend upon them as food or hosts would not survive.

- *Familiarity with various life forms (predators & pests) and their life cycles, patterns of feeding & habitats they prefer helps develop appropriate means of biocontrol.*




*Infographic: Biocontrol agents · जैव नियंत्रण कारक*

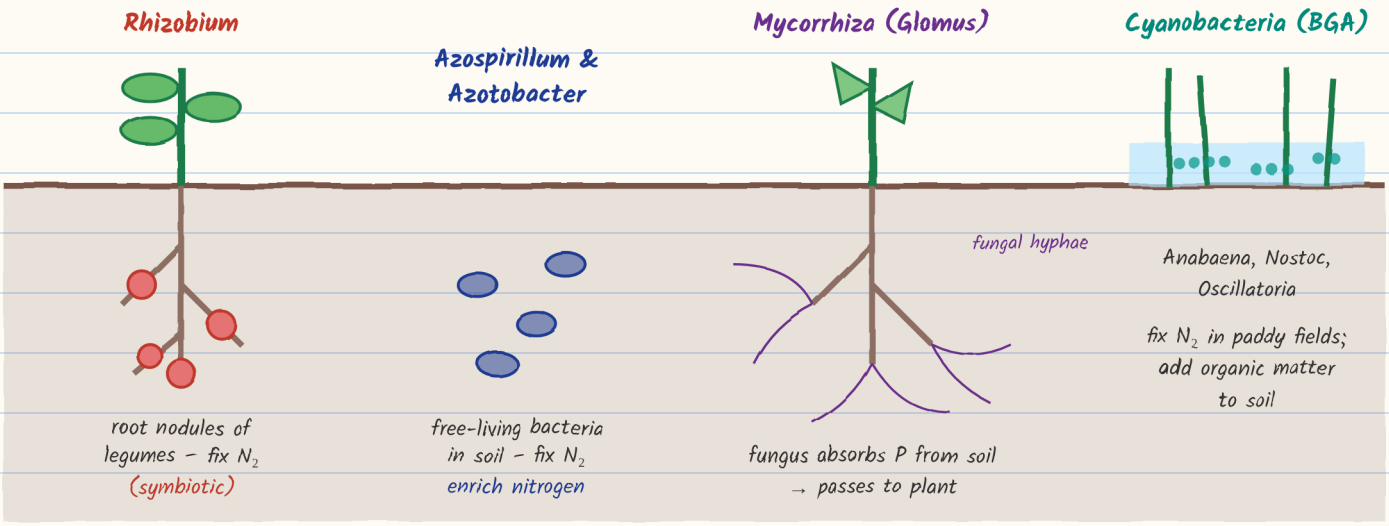
## Examples of biocontrol उदाहरण

- **Ladybird** (with red & black markings) → gets rid of aphids. **Dragonflies** → useful to get rid of mosquitoes.
- ***Bacillus thuringiensis* (Bt)** – microbial biocontrol agent to control **butterfly caterpillars**.
  - Available in **sachets as dried spores**, mixed with water & sprayed onto vulnerable plants such as **brassicas & fruit trees**.
  - Eaten by insect larvae → in the **gut of larvae, toxin is released** → larvae get killed.
  - Bacterial disease kills caterpillars but leaves other insects unharmed.
  - Through genetic engineering, ***B. thuringiensis* toxin genes** introduced into plants → resistant to insect pests, e.g. Bt-cotton.
- ***Trichoderma*** – fungus species; **free-living**, very common in **root ecosystems**; effective biocontrol agents of **several plant pathogens**.
- **Baculoviruses** – pathogens that attack **insects & other arthropods**. Majority used as biological control agents belong to genus *Nucleopolyhedrovirus*.
  - Excellent candidates for **species-specific, narrow spectrum insecticidal** applications.
  - **No negative impacts** on plants, mammals, birds, fish or even non-target insects.
  - Especially desirable in IPM (Integrated Pest Management) programmes or in treating **ecologically sensitive areas**.

# 6. Microbes as Biofertilisers / जैव उर्वरक के रूप में सूक्ष्मजीव

- Chemical fertilisers → **pollution**; so need to switch to **organic farming** & use of biofertilisers.
- **Biofertilisers** (जैव उर्वरक) = organisms that enrich the nutrient quality of the soil.

- Main sources: **bacteria, fungi & cyanobacteria.**




*Infographic: Types of biofertilisers · जैव उर्वरकों के प्रकार*

| Biofertiliser | Example | Role |
|---|---|---|
| **Symbiotic bacteria** | *Rhizobium* | Forms **root nodules** on **leguminous** plants; fixes **atmospheric nitrogen** into organic forms used by plant as nutrient |
| **Free-living bacteria** | *Azospirillum & Azotobacter* | Free-living in soil; fix atmospheric nitrogen → enrich nitrogen content of soil |
| **Fungi – Mycorrhiza** (कवकमूल) | Genus *Glomus* | Symbiotic association of fungi with plants. Fungal symbiont **absorbs phosphorus** from soil & passes it to plant. Plants with mycorrhiza also show: **resistance to root-borne pathogens**, **tolerance to salinity & drought**, overall increase in plant growth & development |
| **Cyanobacteria** (blue-green algae) | *Anabaena, Nostoc, Oscillatoria* | **Autotrophic** microbes in aquatic & terrestrial environments; many fix atmospheric nitrogen. Important biofertilisers in **paddy (rice) fields**. Also **add organic matter** to soil & increase its fertility |

📌 **Note:** In India, a number of biofertilisers are available commercially in the market, and farmers use these regularly in their fields to replenish soil nutrients & reduce dependence on chemical fertilisers.

## ⚡ Quick Revision – Microbe → Use / त्वरित पुनरावृत्ति

| Microbe | Use |
|---|---|
| *Lactobacillus (LAB)* | Curd; lactic acid; ↑ vitamin $B_{12}$ |
| *Saccharomyces cerevisiae* | Bread (baker's yeast), beverages (brewer's yeast), ethanol |
| *Propionibacterium sharmanii* | Swiss cheese (holes – $CO_2$) |
| *Penicillium notatum* | Penicillin |
| *Aspergillus niger* | Citric acid |
| *Acetobacter aceti* | Acetic acid |
| *Clostridium butylicum* | Butyric acid |
| *Streptococcus* | Streptokinase – clot buster |
| *Trichoderma polysporum* | Cyclosporin A – immunosuppressant |
| *Monascus purpureus* | Statins – lower cholesterol |
| *Methanobacterium* | Biogas (methanogen) |
| *Bacillus thuringiensis* | Biocontrol of caterpillars; Bt-cotton |
| *Trichoderma (species)* | Biocontrol of plant pathogens |
| *Nucleopolyhedrovirus* | Baculovirus – species-specific insecticide (IPM) |
| *Rhizobium, Azotobacter, Azospirillum* | $N_2$-fixing biofertilisers |
| *Glomus* | Mycorrhiza – phosphorus absorption |
| *Anabaena, Nostoc, Oscillatoria* | Cyanobacteria – $N_2$ fixation in paddy fields |

📌 **Careful:** *Trichoderma* ***polysporum*** → cyclosporin A (medicine). *Trichoderma* species in soil → **biocontrol**. Don't mix them up!

## ⭐ Exam Corner / परीक्षा उपयोगी प्रश्न

### 1-Mark Questions 1M

**Q1. Which vitamin is increased in curd by LAB? / LAB दही में कौन-सा विटामिन बढ़ाते हैं?**

→ Vitamin $B_{12}$.

**Q2. Name the bacterium responsible for large holes in Swiss cheese.**

→ *Propionibacterium sharmanii*.

**Q3. Name the microbe used to produce citric acid.**

→ *Aspergillus niger*.

**Q4. What is a 'clot buster'? Name its source.**

→ Streptokinase; from Streptococcus.

**Q5. Name the source of statins and their use.**

→ Yeast Monascus purpureus; lower blood cholesterol.

**Q6. Which alcoholic beverages are produced with distillation?**

→ Whisky, brandy, rum.

**Q7. Name the genus of baculoviruses used as biocontrol agents.**

→ Nucleopolyhedrovirus.

**Q8. Name a fungus that forms mycorrhiza.**

→ Glomus.

## 2/3-Mark Questions 2–3M

**Q9. How do LAB convert milk into curd? Mention two benefits.**

→ Produce acids that coagulate & partially digest milk proteins; ↑ vitamin $B_{12}$, check harmful microbes in stomach.

**Q10. Describe the discovery of penicillin.**

→ Fleming; Staphylococci culture; mould Penicillium notatum inhibited growth; Chain & Florey established potential; Nobel 1945.

**Q11. What is BOD? What does a high BOD indicate?**

→ $O_2$ consumed if all organic matter in 1 L water oxidised by bacteria; high BOD = more organic matter = more polluted.

**Q12. What are flocs? What is activated sludge?**

→ Masses of bacteria with fungal filaments (mesh-like) in aeration tank; sedimented flocs in settling tank = activated sludge.

**Q13. Why is cattle dung used in biogas plants?**

→ Rich in methanogens (from rumen) which produce methane anaerobically from cellulosic material.

**Q14. How does Bt act as a biocontrol agent?**

→ Spores sprayed; eaten by caterpillars; toxin released in gut kills larvae; other insects unharmed.

**Q15. Why are baculoviruses ideal for IPM?**

→ Species-specific, narrow spectrum; no harm to plants, mammals, birds, fish, non-target insects.

**Q16. Name the immunosuppressant used in organ transplants and its source.**

→ *Cyclosporin A; Trichoderma polysporum.*

## 5-Mark Questions SM ★★★

**Q17. Describe primary and secondary treatment of sewage. Why is the secondary treatment called biological treatment?**

→ *Filtration & sedimentation → primary sludge & effluent; aeration tank (flocs, BOD ↓) → settling tank (activated sludge) → anaerobic digester (biogas); microbes do the treatment.*

**Q18. Explain the structure and working of a biogas plant with a diagram. Who developed this technology in India?**

→ *Concrete tank, slurry, floating cover, gas outlet, spent slurry as fertiliser; methanogens; IARI & KVIC.*

**Q19. What are biofertilisers? Describe the role of any four.**

→ *Rhizobium, Azotobacter/Azospirillum, mycorrhiza (Glomus), cyanobacteria.*

**Q20. Give an account of microbes used in production of chemicals, enzymes and bioactive molecules.**

→ *Acids table + lipases, pectinases, proteases, streptokinase, cyclosporin A, statins.*

✏ **Diagrams to practise / अभ्यास हेतु चित्र:**

1. *Biogas plant* ⭐
2. *Flowchart of sewage treatment* ⭐
3. *Swiss cheese / Penicillium (identify)*
4. *Root nodules of legume (Rhizobium)*

🎯 **Last-minute tips:** *Always write* ***scientific names in italics/underlined*** · *Learn microbe → product pairs (high-scoring 1-markers!)* · *In sewage answers use keywords* ***flocs, BOD, activated sludge, anaerobic sludge digester, biogas*** · *Biogas:* ***methanogens, Methanobacterium, rumen, gobar gas, IARI & KVIC.***

~ All the best! / शुभकामनाएँ! ~