

CUET · BIOLOGY · CLASS XII · CODE 304

# Microbes in Human Welfare

CUET unit: Biology and Human Welfare → Microbes in Human Welfare

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## Snapshot

- Establishes that microbes (bacteria, fungi, viruses, protozoa, viroids, prions) are not just pathogens — they drive household fermentations, industrial bioprocesses, sewage treatment, biogas, biocontrol and soil enrichment.
- Heavy on names: students must memorise the exact microbe linked to each product (Lactobacillus → curd, Saccharomyces cerevisiae → bread/ethanol, Propionibacterium sharmanii → Swiss cheese, Penicillium notatum → penicillin, Methanobacterium → biogas, Bacillus thuringiensis → caterpillars, Rhizobium / Glomus / Anabaena → biofertilisers).
- Process literacy is tested: primary vs secondary sewage treatment, flocs, BOD, activated sludge, anaerobic sludge digesters, biogas composition.
- CUET routinely converts the Nobel-Prize discovery (Fleming–Chain–Florey, 1945) and the Ganga/Yamuna Action Plan facts into one-liners.

## Detailed Notes

### 2.1 Core concepts

- Microbes are ubiquitous — present in soil, water, air, inside our bodies and those of other animals and plants, and even at sites where no other life-form could survive — deep inside geysers (thermal vents) where temperature may be as high as **100° C**, deep in the soil, under metres of snow and in highly acidic environments. The group is **diverse**: protozoa, bacteria, fungi, microscopic animal and plant viruses, **viroids** and **prions** (proteinaceous infectious agents). Bacteria and many fungi can be grown on nutritive media to form colonies visible to the naked eye (NCERT §8 intro, pp. 149–150).
- **Curd production:** Micro-organisms such as **Lactobacillus** and others, commonly called **lactic acid bacteria (LAB)**, grow in milk and convert it to curd. During growth LAB produce acids that coagulate and partially digest milk proteins; a small amount of curd added to fresh milk as inoculum/starter contains millions of LAB; at suitable temperatures they multiply, converting milk to curd, and also improve nutritional quality by increasing **vitamin B<sub>12</sub>**. In the stomach, LAB also play a beneficial role in checking disease-causing microbes (NCERT §8.1, p. 151).
- **Dosa, idli, bread:** The dough used for foods such as dosa and idli is fermented by bacteria; the puffed-up appearance is due to **CO<sub>2</sub>** production. Bread dough is

fermented using **baker's yeast** — *Saccharomyces cerevisiae*. A number of traditional drinks and foods are also produced by microbial fermentation. '**Toddy**', a traditional drink of southern India, is made by fermenting palm sap; fish, soyabean and bamboo-shoots are also fermented to make foods (NCERT §8.1, p. 151).

- **Cheeses:** One of the oldest food items in which microbes were used. Different varieties have characteristic texture, flavour and taste from the microbes used. The large holes in '**Swiss cheese**' are due to large CO<sub>2</sub> production by a bacterium named *Propionibacterium sharmanii*. '**Roquefort cheese**' is ripened by growing a specific fungus on it, which imparts a particular flavour (NCERT §8.1, p. 151).
- **Industrial fermentation vessels** are called **fermentors**. **Fermented beverages:** Microbes — especially yeasts — have been used from time immemorial to produce **wine, beer, whisky, brandy** and **rum**. The same yeast, *Saccharomyces cerevisiae* (called brewer's yeast for this purpose), is used to ferment malted cereals and fruit juices to produce ethanol. Depending on the raw material and processing, different alcoholic drinks are obtained. **Wine and beer are produced without distillation, while whisky, brandy and rum are produced by distillation** of the fermented broth (NCERT §8.2.1, pp. 151–152).
- **Antibiotics** (Greek anti = "against"; bio = "life" → "against life" for pathogens, but "pro-life" for humans) are chemical substances produced by some microbes that can kill or retard the growth of other (disease-causing) microbes. **Penicillin** was the first antibiotic — a **chance discovery by Alexander Fleming** while working on **Staphylococci**, who observed a mould around which **Staphylococci** could not grow; he named the substance after the mould *Penicillium notatum*. Its full potential as an effective antibiotic was established later by **Ernest Chain and Howard Florey**; the antibiotic was extensively used to treat American soldiers wounded in **World War II**. **Fleming, Chain and Florey were awarded the Nobel Prize in 1945** for this discovery. Antibiotics improved capacity to treat plague, whooping cough (kali khansi), diphtheria (gal ghotu) and leprosy (kusht rog) (NCERT §8.2.2, pp. 152–153).
- **Chemicals, enzymes and bioactive molecules:** Microbes commercialise the production of organic acids, alcohols and enzymes. *Aspergillus niger* (a fungus) → **citric acid**; *Acetobacter aceti* (a bacterium) → **acetic acid**; *Clostridium butylicum* (a bacterium) → **butyric acid**; *Lactobacillus* (a bacterium) → **lactic acid**; *Saccharomyces cerevisiae* → **ethanol**. **Lipases** are used in detergent formulations to remove oily stains; **pectinases and proteases** clarify bottled fruit juices; **Streptokinase** produced by *Streptococcus* (modified by genetic engineering) is a "**clot buster**" for myocardial infarction patients. **Cyclosporin A** from the fungus *Trichoderma polysporum* is an **immunosuppressive agent** for organ-transplant patients; **Statins** produced by the yeast *Monascus purpureus* are **blood-cholesterol-lowering agents** acting by competitively inhibiting the enzyme responsible for cholesterol synthesis (NCERT §8.2.3, p. 153).
- **Sewage treatment** is necessary because untreated municipal waste-water (sewage) — containing large amounts of organic matter and pathogenic microbes —

cannot be discharged directly into natural water bodies. Treatment in **sewage treatment plants (STPs)** uses **heterotrophic microbes** naturally present in sewage and proceeds in two stages.

- **Primary treatment** physically removes particles by filtration and sedimentation — first sequential filtration removes floating debris, then sedimentation removes the grit (soil and small pebbles); all settled solids form **primary sludge**, while the supernatant is the effluent passed to secondary treatment (NCERT §8.3, pp. 153–154).
- **Secondary (biological) treatment:** The primary effluent enters large aeration tanks where it is constantly agitated mechanically and air is pumped in. This grows aerobic microbes into **flocs** — masses of bacteria associated with fungal filaments forming mesh-like structures. The microbes consume the major part of the organic matter, **significantly reducing the BOD** of the effluent. **BOD (biochemical oxygen demand)** is the amount of oxygen that would be consumed if all the organic matter in one litre of water were oxidised by bacteria; BOD measures the rate of uptake of oxygen by microorganisms in a sample and is an indirect measure of organic matter — **the greater the BOD of waste water, the more its polluting potential**. After significant BOD reduction the effluent is passed to a settling tank where the flocs sediment as **activated sludge**; a small part is recycled into the aeration tank as inoculum; the rest is pumped into large **anaerobic sludge digesters** where anaerobic bacteria digest the bacteria and fungi in the sludge producing a mixture of methane, hydrogen sulphide and carbon dioxide — these gases form **biogas**, used as an inflammable source of energy. The treated effluent is generally released into natural water bodies (NCERT §8.3, p. 154).
- **Ganga Action Plan** and **Yamuna Action Plan** were initiated by the Ministry of Environment and Forests to build sewage treatment plants so that only treated sewage is discharged into these rivers (NCERT §8.3, p. 155).
- **Biogas** is a mixture of gases (predominantly **methane**) produced by microbial activity and usable as fuel. The type of gas depends on the microbes and substrates. Certain bacteria that grow **anaerobically on cellulosic material** produce large amounts of methane along with  $\text{CO}_2$  and  $\text{H}_2$  — these are collectively called **methanogens**, and a common bacterium is *Methanobacterium*. They occur in anaerobic sludge during sewage treatment and also in the **rumen of cattle** (a part of stomach) — there they help digest cellulose and play an important role in cattle nutrition. Cattle dung (gobar) is rich in these bacteria, so dung can be used to generate biogas, commonly called **gobar gas**. A biogas plant consists of a concrete tank (10–15 ft deep) into which a slurry of dung is fed; a floating cover rises as gas is produced; the gas is supplied through a pipe to nearby houses, and the spent slurry is removed through another outlet for use as fertiliser. The biogas technology was developed in India mainly by **IARI (Indian Agricultural Research Institute)** and **KVIC (Khadi and Village Industries Commission)** (NCERT §8.4, pp. 155–156).

- Biocontrol agents:** Biocontrol is the use of biological methods to control plant diseases and pests, in place of toxic insecticides, pesticides and weedicides. The organic farmer believes biodiversity furthers health and seeks to keep pests at manageable levels rather than eradicate them. Familiar examples — the **Ladybird** beetle controls **aphids**; **Dragonflies** control **mosquitoes**. **Bacillus thuringiensis** (Bt) is a microbial biocontrol agent against butterfly caterpillars: it is available as dried spores in sachets, mixed with water and sprayed onto plants (brassicas, fruit trees); the larvae ingest the spores and the toxin is released in the larval gut, killing the caterpillar while leaving other insects unharmed. *B. thuringiensis* toxin genes have been engineered into plants — **Bt-cotton** is one example. **Trichoderma** species are free-living root-ecosystem fungi that biocontrol several plant pathogens.

**Baculoviruses** in the genus **Nucleopolyhedrovirus** are species-specific, narrow-spectrum insect pathogens with no negative impact on plants, mammals, birds, fish or non-target insects — ideal for **Integrated Pest Management (IPM)** programmes and ecologically sensitive areas (NCERT §8.5, pp. 156–157).
- Biofertilisers** are organisms that enrich the nutrient quality of the soil. Main sources are **bacteria, fungi and cyanobacteria**. **Rhizobium** forms symbiotic root nodules on leguminous plants and fixes atmospheric nitrogen into organic forms used by the plant; other bacteria — **Azospirillum** and **Azotobacter** — fix atmospheric nitrogen while **free-living in the soil**, enriching soil nitrogen. Fungi form symbiotic associations with plants called **mycorrhiza**; many members of the genus **Glomus** form mycorrhiza — the fungal symbiont absorbs **phosphorus** from soil and passes it to the plant, and the plant also benefits from resistance to root pathogens, tolerance to salinity and drought, and overall growth. **Cyanobacteria** — **Anabaena**, **Nostoc**, **Oscillatoria** — are autotrophic microbes that fix atmospheric nitrogen and, in **paddy fields**, serve as important biofertilisers; blue-green algae also add organic matter and increase soil fertility (NCERT §8.6, pp. 157–158).

## 2.2 Definitions to memorise

Term	Definition	Page
Lactic Acid Bacteria (LAB)	Bacteria such as <i>Lactobacillus</i> that grow in milk, produce acids that coagulate milk proteins, converting milk to curd	151
Baker's yeast	<i>Saccharomyces cerevisiae</i> — used to ferment bread dough; same species also called brewer's yeast for ethanol production	151, 152
Fermentor	Very large vessel used for growing microbes on industrial scale	151
Antibiotic	Chemical substance produced by some microbes that kills or retards growth of other (disease-causing) microbes	152
Primary sludge	All solids that settle out during primary (physical) sewage treatment	154
Flocs	Masses of aerobic bacteria associated with fungal filaments forming mesh-like structures in aeration tanks	154

Term	Definition	Page
BOD	Biochemical Oxygen Demand — amount of O <sub>2</sub> consumed if all organic matter in 1 L of water were oxidised by bacteria; higher BOD = more pollution	154
Activated sludge	Sediment of bacterial flocs from the settling tank after secondary treatment	154
Anaerobic sludge digesters	Large tanks where anaerobic bacteria digest the sludge, producing biogas	154
Methanogens	Bacteria that grow anaerobically on cellulosic material producing CH <sub>4</sub> , CO <sub>2</sub> and H <sub>2</sub> ; e.g. Methanobacterium	155
Biogas	Mixture of gases (predominantly methane) produced by microbial activity, usable as fuel	155
Gobar gas	Biogas produced from cattle dung (gobar) rich in methanogens	155
Biocontrol	Use of biological methods (predators, parasites, pathogens) to control plant pests and diseases	156
Bt	Bacillus thuringiensis — bacterial biocontrol against caterpillars; toxin acts in larval gut	157
Bt-cotton	Cotton plant engineered with B. thuringiensis toxin gene to resist insect attack	157
Baculovirus	Insect-pathogenic virus (genus Nucleopolyhedrovirus) used as narrow-spectrum biopesticide	157
IPM	Integrated Pest Management — biocontrol-led programme that preserves non-target insects	157
Mycorrhiza	Symbiotic association of fungi (e.g. Glomus) with plant roots — fungus absorbs P and supplies it to plant	158
Biofertilisers	Organisms (bacteria, fungi, cyanobacteria) that enrich the nutrient quality of soil	158
Free-living N-fixers	Soil bacteria like Azospirillum and Azotobacter that fix atmospheric N <sub>2</sub> without a plant partner	158
Symbiotic N-fixer	Bacterium such as Rhizobium that fixes N <sub>2</sub> inside the root nodule of legumes	158
Cyanobacterial biofertilisers	Anabaena, Nostoc, Oscillatoria — autotrophic N <sub>2</sub> -fixers important in paddy fields	158

### 2.3 Diagrams / processes to remember

- **Figure 8.1 (p. 150):** Bacteria shapes — rod, spherical, rod-shaped with flagella.
- **Figure 8.2 (p. 150):** Viruses — bacteriophage (head, collar, tail plate, pins, prongs), adenovirus (respiratory infections), rod-shaped TMV.
- **Figure 8.3 (p. 150):** Bacterial and fungal colonies on petri dishes.

- **Figures 8.4 and 8.5 (p. 152):** Fermentors and fermentation plant.
- **Figure 8.6 (p. 154):** Secondary (biological) sewage treatment — aeration tank.
- **Figure 8.7 (p. 155):** Aerial view of a sewage treatment plant.
- **Figure 8.8 (p. 156):** Typical biogas plant — dung + water inlet, digester, floating gas-holder containing  $\text{CH}_4 + \text{CO}_2$ , sludge outlet.
- **Process flow to memorise (Sewage):** Filtration → grit sedimentation → primary sludge + effluent → aeration tank (flocs grow, BOD drops) → settling tank → activated sludge (part recycled) → anaerobic digester → biogas + treated effluent to river.

## 2.4 Common confusions / NTA trap points

- **Penicillium notatum vs Penicillium chrysogenum / Saccharomyces** — NCERT explicitly says Fleming named penicillin after **Penicillium notatum**; don't pick chrysogenum in a NCERT-grounded MCQ.
- **Propionibacterium sharmanii (Swiss cheese) vs Roquefort (a fungus, unnamed in NCERT)** — students often swap; only Swiss cheese has the named bacterium.
- **Cyclosporin A from Trichoderma polysporum** (a fungus, immunosuppressant) vs **Trichoderma** (free-living biocontrol fungus). Same genus, different roles — NCERT mentions both.
- **Statins source = Monascus purpureus (a yeast)** — not a bacterium, not Saccharomyces.
- **Free-living N-fixers (Azospirillum, Azotobacter) vs symbiotic (Rhizobium) vs cyanobacterial N-fixers (Anabaena, Nostoc, Oscillatoria)** — NTA loves these matching questions.
- **Methanogens like Methanobacterium are anaerobic**, found both in sludge digesters and the cattle rumen — not aerobic flocs.
- **Bt toxin is released in the larval gut**, not on plant surface — and Bt kills caterpillars (lepidopteran larvae), not all insects.
- **Wine/beer = not distilled; whisky/brandy/rum = distilled.**
- **Aspergillus niger (citric acid) ≠ Acetobacter aceti (acetic acid)** — same product family, different organisms.
- **BOD direction** — higher BOD = MORE polluting, not less. Distractors often invert this.
- Streptokinase = **clot buster** from Streptococcus; do not confuse with streptomycin (antibiotic).

## 2.5 Key microbes → product / process (NCERT-cited)

Microbe	Product / role	Process or use	NCERT page
Lactobacillus (LAB)	Lactic acid; curd from milk	Coagulate milk proteins; raise B <sub>12</sub> ; check pathogens in stomach	151, 153
Saccharomyces cerevisiae (baker's/brewer's yeast)	Bread dough rise; ethanol; wine/beer/spirits	Ferments malted cereals and fruit juices	151–153
Propionibacterium sharmanii	Large CO <sub>2</sub> holes in Swiss cheese	Bacterial cheese ripening	151
Specific fungus	Roquefort cheese ripening	Imparts particular flavour	151
Penicillium notatum	Penicillin (first antibiotic)	Fleming → Chain & Florey; Nobel 1945; WW-II soldier treatment	152
Aspergillus niger	Citric acid	Industrial acid production	153
Acetobacter aceti	Acetic acid	Industrial acid production	153
Clostridium butylicum	Butyric acid	Industrial acid production	153
Streptococcus (engineered)	Streptokinase	Clot buster in myocardial infarction	153
Trichoderma polysporum	Cyclosporin A	Immunosuppressant for organ transplants	153
Monascus purpureus	Statins	Lower blood cholesterol via enzyme inhibition	153
Aerobic flocs (bacteria + fungi)	Reduce BOD of sewage	Secondary treatment in aeration tank	154
Anaerobic sludge bacteria	Biogas (CH <sub>4</sub> + H <sub>2</sub> S + CO <sub>2</sub> )	Anaerobic sludge digester	154
Methanobacterium (methanogen)	Methane from cellulosic substrate	Biogas plant, cattle rumen	155
Bacillus thuringiensis (Bt)	Insecticidal toxin in larval gut	Spray against butterfly caterpillars; Bt-cotton	157
Trichoderma	Biocontrol of root pathogens	Free-living root-ecosystem fungus	157
Nucleopolyhedrovirus (Baculovirus)	Species-specific insecticide	Narrow-spectrum biopesticide for IPM	157
Rhizobium	Symbiotic N <sub>2</sub> fixation	Root nodules of legumes	158

Microbe	Product / role	Process or use	NCERT page
Azospirillum, Azotobacter	Free-living N <sub>2</sub> fixation	Soil enrichment	158
Glomus (mycorrhiza)	Absorbs phosphorus, gives to plant	Resistance to pathogens, salinity, drought	158
Anabaena, Nostoc, Oscillatoria	N <sub>2</sub> -fixing cyanobacteria	Important biofertilisers in paddy fields	158

## Practice MCQs

**Q1.** Which of the following microorganisms is responsible for the large holes seen in 'Swiss cheese' due to the production of large amounts of CO<sub>2</sub>?

- A. Lactobacillus acidophilus
- B. Propionibacterium sharmanii
- C. Saccharomyces cerevisiae
- D. Monascus purpureus

**Q2.** Penicillin was named after the mould from which it was first obtained. Which of the following correctly pairs the antibiotic with that mould?

- A. Penicillin — Aspergillus niger
- B. Penicillin — Trichoderma polysporum
- C. Penicillin — Penicillium notatum
- D. Penicillin — Monascus purpureus

**Q3. Match the microbe with the product it yields (as per NCERT):** | Microbe | Product | |---|---| | (i) *Aspergillus niger* | (1) Cyclosporin A | | (ii) *Acetobacter aceti* | (2) Citric acid | | (iii) *Trichoderma polysporum* | (3) Statins | | (iv) *Monascus purpureus* | (4) Acetic acid |

- A. (i)-2, (ii)-4, (iii)-1, (iv)-3
- B. (i)-4, (ii)-2, (iii)-3, (iv)-1
- C. (i)-2, (ii)-4, (iii)-3, (iv)-1
- D. (i)-1, (ii)-3, (iii)-4, (iv)-2

 **9 more MCQs + answer key**

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## PYQ Alignment

This chapter is among the highest-yielding portions of the CUET 304 Biology unit "Biology and Human Welfare", typically contributing 6–10 MCQs per year across CUET 2023-25. Recurring favourites are: microbe–product matching (*Lactobacillus*, *S. cerevisiae*, *Propionibacterium*, *Aspergillus*, *Acetobacter*, *Clostridium*, *Monascus*, *Trichoderma*), the Fleming–Chain–Florey 1945 fact, BOD/primary-vs-secondary treatment distinctions, methanogens and biogas composition, Bt mode of action, and *Rhizobium*/*Glomus*/*Anabaena* biofertiliser identification.

### CUET 2025 — Actual PYQs from this chapter

**Q.5 (CUET 2025)** Match List-I (Producer) with List-II (Acid). Producer Acid (A) *Clostridium butylicum* (i) Lactic acid (B) *Aspergillus niger* (ii) Butyric acid (C) *Acetobacter aceti* (iii) Citric acid (D) *Lactobacillus* (iv) Acetic acid

- A) [option not extracted — see source]
- B) [option not extracted — see source]
- C) [option not extracted — see source]
- D) [option not extracted — see source]

**Tests:** aligns with §2 (microbes in human welfare) **Answer:** Not in extracted key — verify against official NTA key

**Q.19 (CUET 2025)** Match List-I (Product) with List-II (Producer). Product Producer (A) Citric acid (i) *Trichoderma polysporum* (B) Ethanol (ii) *Monascus purpureus* (C) Statins (iii) *Saccharomyces cerevisiae* (D) Cyclosporin -A (iv) *Aspergillus niger*

- A) [option not extracted — see source]
- B) [option not extracted — see source]
- C) [option not extracted — see source]
- D) [option not extracted — see source]

**Tests:** aligns with §2 (microbes in human welfare) **Answer:** Not in extracted key — verify against official NTA key

**Q.23 (CUET 2025)** Baculoviruses are pathogens that attack:

- A) Insects
- B) Roundworms
- C) Molluscs
- D) Birds

**Tests:** aligns with §2 (microbes in human welfare) **Answer:** Not in extracted key — verify against official NTA key

**Q.31 (CUET 2025)** Arrange products formed during sewage treatment in correct sequence: (A) Biogas (B) Activated sludge (C) Floccs (D) Primary sludge

- A) [option not extracted — see source]
- B) [option not extracted — see source]
- C) [option not extracted — see source]
- D) [option not extracted — see source]

**Tests:** aligns with §2 (microbes in human welfare) **Answer:** Not in extracted key — verify against official NTA key

## CUET 2023 — Actual PYQs from this chapter

**Q.24 (CUET 2023)** Which of the following is not a nitrogen-fixing microorganism?

- A) *Azotobacter*
- B) *Oscillatoria*
- C) *Acetobacter*
- D) *Nostoc*

**Tests:** aligns with §2 (biofertilizers / nitrogen-fixing microbes) **Answer:** Not in extracted key — verify against official NTA key

**Q.25 (CUET 2023)** The large holes in Swiss cheese are due to:

- A) Production of oxygen
- B) Citric acid
- C) Production of carbon dioxide

- D) Ethyl alcohol

**Tests:** aligns with §2 (microbes in human welfare) **Answer:** Not in extracted key — verify against official NTA key

**Q.26 (CUET 2023)** Which of the following is not a cyanobacteria?

- A) Nostoc
- B) Glomus
- C) Anabaena
- D) Oscillatoria

**Tests:** aligns with §2 (microbes in human welfare) **Answer:** Not in extracted key — verify against official NTA key

