

Chapter 8: Microbes in Human Welfare

Comprehensive Study Notes

Class 12 Biology - NCERT Based

EXAM SPRINT - Complete Coverage for NEET and Board Examinations

Introduction

Microbes are the major components of biological systems on Earth besides macroscopic plants and animals. They are present everywhere - in soil, water, air, inside bodies of animals and plants, and even in extreme environments where no other life forms exist.

Key Concepts:

- **Microbes:** Include protozoa, bacteria, fungi, microscopic viruses, viroids, and prions
 - **Ubiquity:** Present in all environments including extreme conditions (100°C geysers, deep soil, acidic environments)
 - **Diversity:** Not all microbes are harmful; many are beneficial to humans
 - **Cultivation:** Bacteria and fungi can be grown on nutritive media forming visible colonies
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8.1 MICROBES IN HOUSEHOLD PRODUCTS

Common Household Applications:

1. Curd Production:

- **Organism:** Lactobacillus and other Lactic Acid Bacteria (LAB)
- **Process:** LAB grow in milk, produce acids that coagulate and digest milk proteins

- **Benefits:**
 - Increases vitamin B₁₂ content
 - LAB in stomach check disease-causing microbes
- **Mechanism:** Small amount of curd as inoculum contains millions of LAB

2. Fermented Foods:

Dosa and Idli:

- **Process:** Dough fermentation by bacteria
- **Product:** CO₂ gas production causes puffed appearance
- **Metabolic Pathway:** Fermentation producing CO₂

Bread Making:

- **Organism:** Baker's yeast (*Saccharomyces cerevisiae*)
- **Process:** Dough fermentation

3. Traditional Beverages and Foods:

- **Toddy:** Fermented palm sap (Southern India)
 - **Fermented Products:** Fish, soybean, bamboo shoots
 - **Cheese Production:**
 - Swiss Cheese: Large holes due to CO₂ production by *Propionibacterium sharmanii*
 - Roquefort Cheese: Specific fungi provide particular flavor
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8.2 MICROBES IN INDUSTRIAL PRODUCTS

8.2.1 Fermented Beverages

Production Process:

- **Organism:** *Saccharomyces cerevisiae* (brewer's yeast)
- **Raw Materials:** Malted cereals and fruit juices
- **Product:** Ethanol
- **Equipment:** Large fermentors for industrial scale production

Types of Alcoholic Beverages:

Without Distillation:

- Wine
- Beer

With Distillation:

- Whisky
- Brandy
- Rum

8.2.2 Antibiotics

Historical Background:

- **Definition:** Anti (against) + bio (life) = against disease-causing organisms
- **Discovery:** Alexander Fleming discovered Penicillin from *Penicillium notatum*
- **Development:** Ernest Chain and Howard Florey established its potential

- **Recognition:** Nobel Prize 1945 (Fleming, Chain, Florey)

Significance:

- First antibiotic discovered by chance
- Used extensively in World War II
- Revolutionized treatment of deadly diseases:
 - Plague
 - Whooping cough (kali khansi)
 - Diphtheria (gal ghotu)
 - Leprosy (kusht rog)

8.2.3 Chemicals, Enzymes and Bioactive Molecules

Acid Producers:

Organism	Type	Product
Aspergillus niger	Fungus	Citric acid
Acetobacter aceti	Bacterium	Acetic acid
Clostridium butylicum	Bacterium	Butyric acid
Lactobacillus	Bacterium	Lactic acid

Commercial Enzymes:

- **Lipases:** Used in detergents for removing oily stains
- **Pectinases & Proteases:** Used for clarifying bottled fruit juices
- **Streptokinase:** From Streptococcus (genetically modified) - clot buster for heart attack patients

Important Bioactive Molecules:

- **Cyclosporin A:** From *Trichoderma polysporum* - immunosuppressive agent for organ transplants
 - **Statins:** From *Monascus purpureus* - blood cholesterol lowering agents
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8.3 MICROBES IN SEWAGE TREATMENT

Sewage Composition:

- **Definition:** Municipal waste water containing human excreta
- **Components:** Large amounts of organic matter and pathogenic microbes
- **Treatment Necessity:** Cannot be discharged directly into water bodies

Treatment Stages:

Primary Treatment:

Physical Processes:

1. **Filtration:** Removal of floating debris
2. **Sedimentation:** Removal of grit (soil and small pebbles)
3. **Products:**
 - Primary sludge (settled solids)
 - Effluent (supernatant for secondary treatment)

Secondary Treatment (Biological Treatment):

Process:

1. **Aeration Tanks:** Primary effluent is agitated mechanically with air pumping
2. **Floc Formation:** Aerobic microbes form flocs (bacterial masses with fungal filaments)

3. **Organic Matter Consumption:** Microbes consume organic matter, reducing BOD

4. **Settling:** Bacterial flocs sediment forming activated sludge

Key Concept - BOD (Biochemical Oxygen Demand):

- **Definition:** Amount of oxygen consumed if all organic matter in 1 liter water is oxidized
- **Significance:**
 - Indirect measure of organic matter
 - Higher BOD = More polluting potential
 - Treatment continues until BOD is significantly reduced

Anaerobic Sludge Digestion:

- **Process:** Anaerobic bacteria digest sludge
- **Products:** Biogas (methane, hydrogen sulphide, CO₂)
- **Application:** Biogas used as energy source

Environmental Impact:

- **Global Application:** Used worldwide for over a century
 - **Challenge:** Increasing urbanization vs limited treatment plants
 - **Government Initiatives:** Ganga Action Plan, Yamuna Action Plan
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8.4 MICROBES IN PRODUCTION OF BIOGAS

Biogas Composition and Production:

- **Definition:** Mixture of gases (predominantly methane) from microbial activity
- **Producers:** Methanogens (collectively called methanogenic bacteria)

- **Example:** Methanobacterium

Sources of Methanogens:

1. **Sewage Treatment:** Anaerobic sludge
2. **Cattle Rumen:** Help in cellulose breakdown
3. **Cattle Dung (Gobar):** Rich in methanogenic bacteria

Biogas Plant Structure:

Components:

- **Concrete Tank:** 10-15 feet deep
- **Slurry:** Dung and bio-waste mixture
- **Floating Cover:** Rises as gas is produced
- **Inlet:** For feeding slurry
- **Gas Outlet:** Connected to pipeline
- **Spent Slurry Outlet:** For fertilizer use

Applications:

- **Rural Areas:** More suitable due to cattle availability
 - **Uses:** Cooking and lighting
 - **Development:** IARI (Indian Agricultural Research Institute) and KVIC (Khadi and Village Industries Commission)
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8.5 MICROBES AS BIOCONTROL AGENTS

Definition:

Use of biological methods for controlling plant diseases and pests as alternative to toxic chemicals.

Principles of Biological Control:

Organic Farming Philosophy:

- **Biodiversity Approach:** More variety = more sustainability
- **Natural Predation:** Relies on natural enemies rather than chemicals
- **Ecosystem Balance:** Complex system of checks and balances
- **Holistic Approach:** Understanding organism interactions in field ecosystem

Biocontrol Examples:

Beneficial Insects:

- **Ladybird Beetles:** Control aphids
- **Dragonflies:** Control mosquitoes

Microbial Biocontrol Agents:

Bacillus thuringiensis (Bt):

- **Target:** Butterfly caterpillars
- **Application:** Dried spores mixed with water, sprayed on plants
- **Mechanism:** Toxin released in insect gut, kills larvae selectively
- **Genetic Engineering:** Bt genes introduced into plants (Bt-cotton)

Trichoderma:

- **Type:** Free-living fungi
- **Application:** Biocontrol of plant pathogens
- **Location:** Common in root ecosystems

Baculoviruses:

- **Type:** Insect pathogens (genus Nucleopolyhedrovirus)
 - **Advantages:**
 - Species-specific action
 - No negative impact on plants, mammals, birds, fish
 - Safe for beneficial insects
 - Suitable for Integrated Pest Management (IPM)
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8.6 MICROBES AS BIOFERTILISERS

Environmental Context:

- **Problem:** Chemical fertilizer pollution
- **Solution:** Shift to organic farming using biofertilisers
- **Definition:** Organisms that enrich soil nutrient quality

Sources of Biofertilisers:

1. Bacteria:

Symbiotic Nitrogen Fixers:

- **Rhizobium:** Forms root nodules in leguminous plants
- **Process:** Fixes atmospheric nitrogen to organic forms

Free-living Nitrogen Fixers:

- **Azospirillum:** Fixes nitrogen while free in soil
- **Azotobacter:** Enriches soil nitrogen content

2. Fungi:

Mycorrhizal Associations:

- **Example:** Glomus species
- **Function:** Absorbs phosphorus from soil, transfers to plant
- **Additional Benefits:**
 - Resistance to root-borne pathogens
 - Tolerance to salinity and drought
 - Enhanced plant growth and development

3. Cyanobacteria:

Characteristics:

- **Type:** Autotrophic microbes
- **Distribution:** Aquatic and terrestrial environments
- **Examples:** Anabaena, Nostoc, Oscillatoria

Applications:

- **Paddy Fields:** Important biofertiliser
- **Soil Enhancement:** Add organic matter, increase fertility

Commercial Availability:

Currently available in Indian markets for regular use by farmers to reduce chemical fertilizer

dependence.

NEET-Specific Important Points

High-Yield Topics for NEET:

1. Microbes in Food Production:

- Lactobacillus in curd formation
- Saccharomyces cerevisiae in bread and alcohol production
- Fermentation processes and products

2. Industrial Applications:

- Antibiotic production and discovery
- Enzyme production and applications
- Bioactive molecule sources

3. Environmental Applications:

- Sewage treatment process
- BOD concept and significance
- Biogas production and composition

4. Agricultural Applications:

- Biocontrol agents and mechanisms
- Biofertiliser types and functions
- Nitrogen fixation processes

Common NEET Question Patterns:

1. Identification Questions:

- Organism-product associations
- Process-location connections
- Application-benefit relationships

2. Process Questions:

- Fermentation mechanisms
- Sewage treatment stages
- Biogas production process

3. Application Questions:

- Biocontrol examples
 - Biofertiliser functions
 - Industrial microbial products
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Memory Aids and Mnemonics

Acid Producing Microbes:

"AACL"

- **A**spergillus niger - Citric acid
- **A**cetobacter aceti - Acetic acid
- **C**lostridium butylicum - Butyric acid
- **L**actobacillus - Lactic acid

Biocontrol Agents:

"BTT-B"

- **B**acillus thuringiensis
- **T**richoderma
- **T**raditional insects (Ladybird, Dragonflies)
- **B**aculoviruses

Biofertiliser Sources:

"RFC"

- **R**hizobium (symbiotic)
- **F**ungi (mycorrhiza)
- **C**yanobacteria (free-living)

Sewage Treatment:

"Primary Physical, Secondary Biological"

- **P**rimaries - **P**hysical removal
 - **S**econdary - **B**iological treatment with BOD reduction
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Practice Questions for NEET

Multiple Choice Questions:

1. The microbe used for production of citric acid is: a) Acetobacter aceti b) Aspergillus niger c) Clostridium butylicum d) Lactobacillus

2. BOD refers to: a) Bacterial oxygen demand b) Biochemical oxygen demand c) Biological oxygen demand d) Biotic oxygen demand
3. Bt-cotton is resistant to: a) Bacterial diseases b) Fungal diseases c) Insect pests d) Viral diseases

Short Answer Questions:

1. Why is secondary treatment in sewage called biological treatment?
2. What is the role of methanogens in biogas production?
3. Name two free-living nitrogen-fixing bacteria used as biofertilisers.

Long Answer Questions:

1. Describe the sewage treatment process with emphasis on the role of microbes.
2. Explain the concept of biocontrol with suitable examples.
3. Discuss the various applications of microbes in industrial production.

Summary Table: Microbes and Their Applications

Application Area	Microbe	Product/Function	Significance
Household	Lactobacillus	Curd formation	Nutritional, digestive health
Household	Saccharomyces	Bread, beverages	Food production
Industrial	Penicillium notatum	Penicillin	Antibiotic therapy
Industrial	Aspergillus niger	Citric acid	Industrial processes
Environmental	Aerobic bacteria	Sewage treatment	Water purification
Energy	Methanobacterium	Biogas	Renewable energy
Agriculture	Bacillus thuringiensis	Biocontrol	Pest management
Agriculture	Rhizobium	Nitrogen fixation	Soil fertility

Key Equations and Processes to Remember

1. Fermentation:

- **Alcoholic:** Glucose $\rightarrow$ Pyruvate $\rightarrow$ CO₂ + Ethanol
- **Lactic Acid:** Glucose $\rightarrow$ Pyruvate $\rightarrow$ Lactic acid

2. Biogas Composition:

- **Primary:** Methane (CH₄)
- **Secondary:** CO₂, H₂S

3. BOD Relationship:

- **Higher BOD = Higher organic matter = Higher pollution**

4. Nitrogen Fixation:

- **Atmospheric N₂ $\rightarrow$ Organic nitrogen compounds** (via Rhizobium, Azotobacter)
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EXAM SPRINT Strategy

Focus Areas:

1. **Memorize organism-product pairs**
2. **Understand process mechanisms**
3. **Practice application-based questions**
4. **Learn environmental significance**
5. **Master biocontrol and biofertiliser concepts**

Quick Revision Points:

- Alexander Fleming discovered Penicillin
- BOD measures organic matter indirectly
- Bt-cotton contains *Bacillus thuringiensis* genes
- Mycorrhiza helps in phosphorus absorption
- Primary treatment is physical, secondary is biological

EXAM SPRINT - Master microbial applications through focused study on organism identification, process understanding, and environmental applications. Regular practice of application-based questions is essential for NEET success.

Source: NCERT Biology Class 12, Chapter 8 - Comprehensive coverage for NEET preparation