Microbial Biotransformation and Applications

Introduction

- Microorganisms are not only used for fermentation but also for **biotransformation**, which refers to the **chemical modification of compounds by microbial cells or enzymes**.
- It is a valuable method for producing **pharmaceuticals, agrochemicals, flavors, fragrances, and fine chemicals**.
- Unlike traditional chemical synthesis, microbial biotransformation occurs under **mild conditions (normal temperature, pH, pressure)** and often shows **high specificity**.

Definition

Microbial biotransformation is the process in which microorganisms (bacteria, fungi, actinomycetes, or yeast) or their enzymes modify a chemical compound into a structurally related product with added value.

Basic Principles

1. **Specificity**
   - Microbes carry out **stereospecific** and **regioselective** transformations (produce desired isomers).
2. **Mild Conditions**
   - Reactions occur at **normal temperature and pressure**, unlike harsh chemical methods.
3. **Eco-friendly**
   - Produces fewer toxic byproducts.
4. **Diverse Reactions Possible**
   - Oxidation, reduction, hydroxylation, deamination, decarboxylation, isomerization, hydrolysis.
5. **Whole Cells or Enzymes**
   - Transformation can be carried out using **whole microbial cells** (living/non-living) or **purified enzymes**.

Microorganisms Involved in Biotransformation

- **Bacteria:** *Pseudomonas*, *Bacillus*, *Escherichia coli*.
- **Fungi:** *Aspergillus*, *Penicillium*, *Rhizopus*.
- **Yeast:** *Saccharomyces cerevisiae*, *Candida*.
- **Actinomycetes:** *Streptomyces* (important for antibiotics).

Types of Biotransformation

1. **Oxidation** – Conversion of alcohols to acids or ketones.
2. **Reduction** – Conversion of ketones/aldehydes to alcohols.
3. **Hydroxylation** – Introduction of the OH group (steroids).

4. **Decarboxylation** – Removal of the CO_2 group.
5. **Deamination** – Removal of the amino group.
6. **Isomerization** – Conversion of glucose to fructose.
7. **Hydrolysis** – Breaking ester bonds (lipases, proteases).

Steps in the Biotransformation Process

1. **Selection of Microorganism** – based on desired transformation.
2. **Substrate Feeding** – supplying precursor chemical.
3. **Microbial Growth / Enzyme Reaction** – incubation under optimal conditions.
4. **Biotransformation Reaction** – substrate modified to a new product.
5. **Product Recovery** – extraction and purification.

Examples of Microbial Biotransformation

1. **Steroid Transformation**
   - *Rhizopus* species hydroxylate steroids.
   - Example: Cortisone → Prednisone (anti-inflammatory drug).
2. **Antibiotic Modification**
   - *Streptomyces* species modify β-lactam antibiotics.
3. **Vitamin Production**
   - Biotransformation of precursors into Vitamin C (Ascorbic acid) using *Acetobacter*.
4. **Flavors and Fragrances**
   - Yeasts transform precursors into **esters** (used in perfumes, food flavoring).
5. **Amino Acid Production**
   - *Corynebacterium glutamicum* → Glutamic acid.
   - *Brevibacterium* → L-lysine.
6. **Bioconversion of Waste**
   - *Pseudomonas* degrades hydrocarbons into useful intermediates.

Applications of Microbial Biotransformation

1. Pharmaceutical Industry

- Production of **steroids (cortisone, prednisone)**.
- Manufacture of **antibiotics** and their derivatives.
- Production of **alkaloids** (morphine derivatives).
- Synthesis of **chiral intermediates** for drug manufacture.

2. Food Industry

- Conversion of **glucose → fructose** (high fructose corn syrup).
- Production of **flavors** (vanillin, esters, alcohols).
- Manufacture of fermented foods (cheese, soy sauce).

3. Agriculture

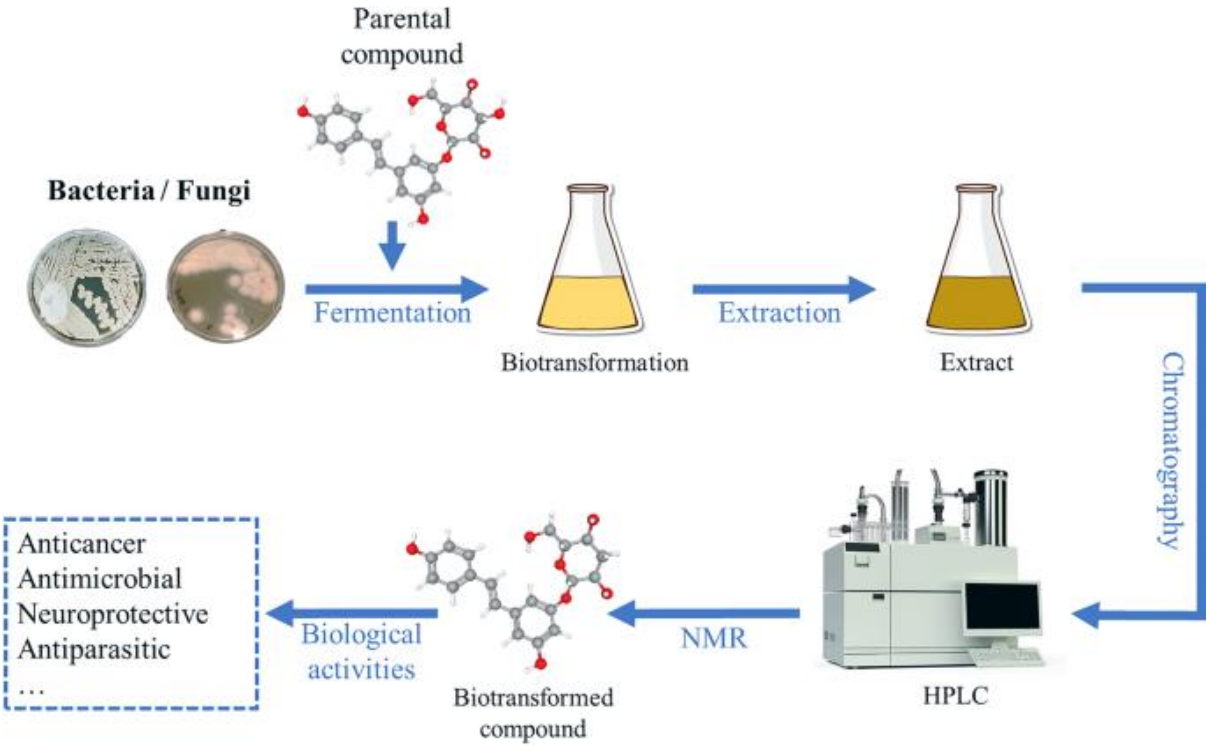
- Bioconversion of pesticides into less toxic forms.
- Production of **biopesticides and biofertilizers**.

4. Environmental Biotechnology

- Bioremediation of pollutants.
- Conversion of toxic compounds into biodegradable products.

5. Industrial Chemicals

- Synthesis of organic acids (citric acid, lactic acid).
- Biopolymers (PHA, PHB) from microbial action.



Advantages over Chemical Synthesis

- High **specificity** (no unwanted isomers).
- Less **energy consumption**.
- **Eco-friendly** process.
- Economical for complex molecules.

Limitations

- Some reactions are **slow**.
- Product yield may be **low**.
- Requires **specific growth conditions**.
- Purification can be **costly**.

Conclusion

Microbial biotransformation is a **powerful natural process** harnessed for **industrial, pharmaceutical, food, agricultural, and environmental applications**.
It provides an **eco-friendly, cost-effective, and highly specific alternative** to chemical synthesis, making it one of the pillars of modern biotechnology.