

Chapter 24

Environmental Sustainability and Biotechnology



Using Nature's Principles, Products, and Processes

- Nature's design process
 - Evolutionary process by natural selection
- Nature's design principles
 - Raw materials
 - Cyclic material flow
 - Process
 - Efficient regulation
- Modern biotechnology
 - Use biological molecules as raw materials
 - Use biological process

Useful Biomolecules and Bioprocesses

- Biomolecules produced by plants and microorganisms
 - Pharmaceuticals
 - Antibiotics, enzyme inhibitors, anti-inflammatory compound, anticoagulants etc
 - Food additive
 - Vanilla, pectin, glycerol
 - Molecules for flavor or aroma
 - Bulk chemicals
 - Acetone, citric acid, acetic acid
 - Fine chemicals
 - Enzymes, plant hormones
 - Nutrient supplement
 - Vitamins, amino acids
 - Whole organism
 - Vaccine, probiotics, baker's yeast, microbial pesticides
- Microbial bioprocesses
 - Yeast fermentation for making wine, bread, beer

Bioprocess Technologies

- **Bioprocess**
 - Use biocatalysts: living organism or enzymes
- **Advantages of bioprocess**
 - **Sustainability**
 - Reproduction of cells
 - **Mild conditions**
 - Water soluble, low temperature, normal atmospheric pressure, neutral pH
 - **Specificity**
 - Highly selective for substrates and products
 - **Can be continually improved**
 - Genetic modification for optimization of the process

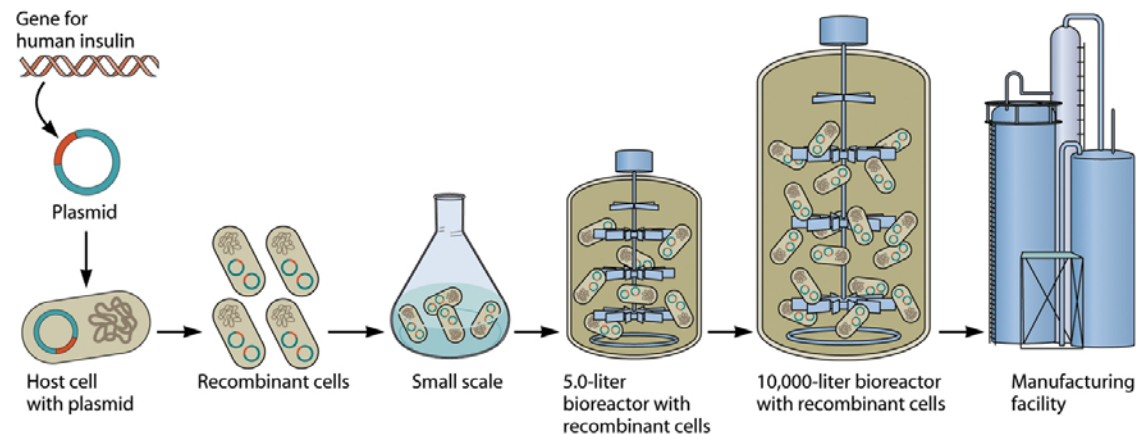
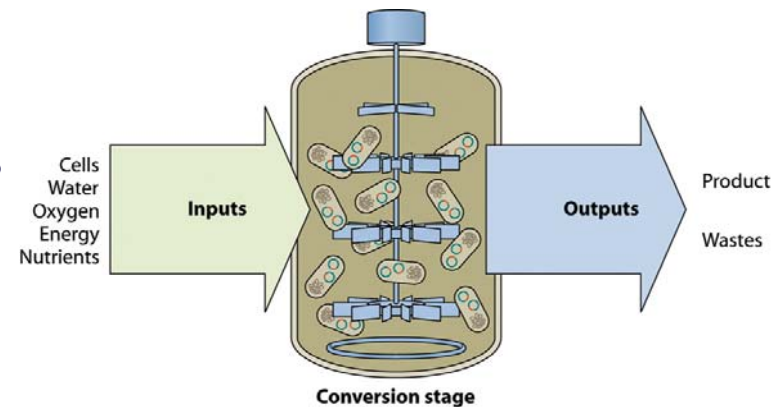
Bioprocess Technologies

- **Disadvantages of bioprocess**
 - Limitations for the processes carried out under extreme conditions
 - Organic solvent
 - High or low temperatures
 - Extreme chemical conditions (high or low pH, high salt)
- **Optimization of biocatalysts**
 - Directed (site-specific) mutagenesis
 - Directed evolution: Random mutagenesis and selection
- **Discovering novel biocatalysts**
 - Extremozymes from extremophiles
 - Bioprospecting: Looking for microbes with desirable metabolic properties
 - Total community genomics: Isolation of an interesting gene from mixture of organisms



Large-Scale Biomanufacturing

- Microbial fermentation (industrial term)
 - Using microbes to manufacture a commercial product
 - Bioreactors (fermentors)
 - Supply of nutrients
 - Optimum environmental conditions
 - Temperature
 - Oxygen
 - pH : add buffers to control pH



Using Biodegradation Pathway

■ Biomass as energy source

■ Biofuel

- Storage of bio energy in other organic molecules
 - Bioethanol, biogas, biodiesel
- Source of biomaterial
 - Sugarcane, corn starch
- Environment vs. cost



■ Biofeedstocks

■ Feed stock chemicals

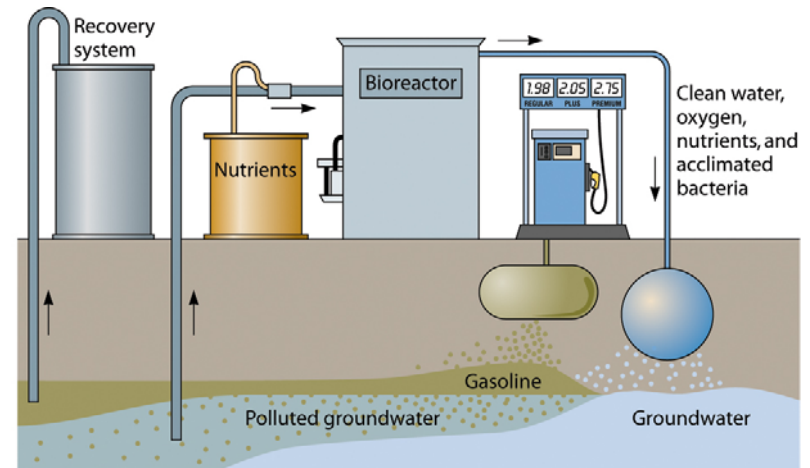
- Building blocks for various consumer products (plastics, polyethylene etc.)
- Glucose as a starting material for producing building blocks

■ The source of biomass

- Natural vegetation
- Growing agricultural crops and trees
- Biological waste products : e.g. cellulose

Bioremediation

- Bioremediation
 - Use microbes to remove pollutants (oil, toxic waste sites)
- Phytoremediation
 - Use plants for cleanup
- Methodology
 - Bioaugmentation
 - Provide nutrients to simulate the activity of preexisting bacteria
 - Addition of new microbes
 - Use metabolic engineering to improve degrading activity



Bioremediation of a gasoline spill