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INTRODUCTION TO BIOENGINEERING

What is Bioengineering?

- **Biological engineering**, or **bioengineering/bio-engineering**, is the application of principles of **biology** and the **tools of engineering** to create usable, tangible, economically viable products.
- **Bio** – the use of biological process
- **Engineering** - making practical application of the knowledge of
  - ✓ mass and heat transfer, kinetics, biocatalysts, biomechanics, bioinformatics, separation and purification processes, bioreactor design, surface science, fluid mechanics, thermodynamics, and polymer science.

(Source- https://en.wikipedia.org/wiki/Biological_engineering)

What is Biotechnology

- **Biotechnology** is the broad area of biology involving living systems and organisms to develop or make products

(UN Convention on Convention on Biological Diversity, Art. 2)

- **Bio** - the use of biological processes
- **technology** - to make useful products

Bioengineering and Biotechnology

- **Biotechnology** is the utilization of **biological processes, organisms or systems** to **produce products** that are anticipated to improve human lives

- **Bioengineering** is the application of the principles of engineering and natural sciences to **improve functions** in plants, animals or microorganisms

History of Biotechnology

- 3 stage of development
  - ✓Microbial technology
  - ✓Cell technology
  - ✓Gen technology

History of Biotechnology

- Biotechnology revolution 1 (begin 20 century): acetone, glycerol, citric acid, riboflavin...
- Biotechnology revolution 2 (after Wold War II): antibiotics, glutamic acid, polysaccharide; achievements in mutation, creating microbial strains for high productivity and efficiency, developing continuous fermentation and immobilized enzymes
- Biotechnology revolution 3 (the mid-1970s): copy and paste DNA, cloning vector, recombinant DNA.

History of Biotechnology

- First two stage: exploit the biological process of invidual cell, no genetic modification – **traditional biotechnology**.
- Third stage – **modern biotechnology**, new era of biotechnology

Tradional Biotechnology

Fermentation, selective breeding, antibiotics

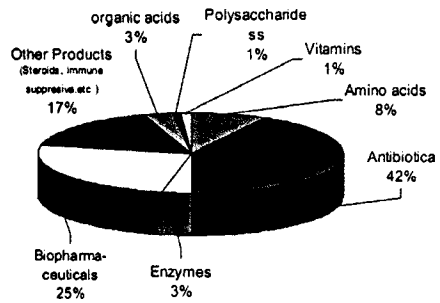
Example of products of traditional biotechnology:

- Bread yeast, soya sauce, yoghurt, glutamate sodium
- Beer, wine, alcohol
- Organic acid (lactic, citric, acetic)
- Antibiotics

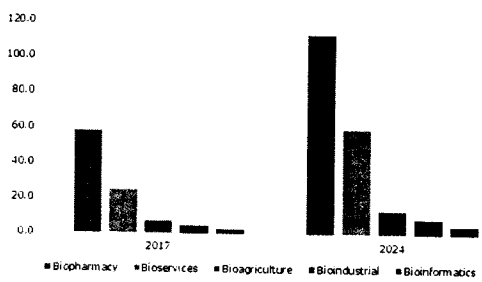
Modern Biotechnology

- Gene cloning
- Genetic engineering
- Recombinant DNA technology

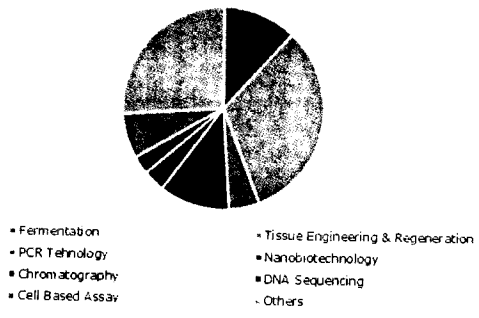
Biotechnology Market share



US Biotechnology Market (USD Billion)



Germany Biotechnology Market Size (USD Billion)



Divisions of Biotechnology

- Green biotechnology ➡ Agricultural biotechnology
  Environmental biotechnology
- White biotechnology ➡ Industrial biotechnology
- Red biotechnology ➡ Medical biotechnology

Divisions of Biotechnology

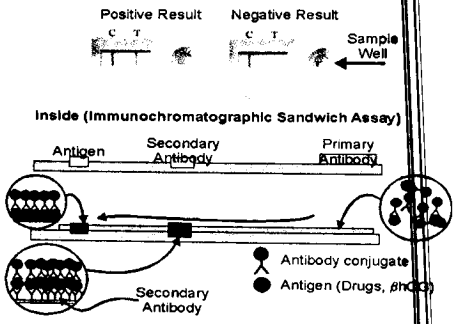
1. **Medical Biotechnology**- diagnostics, pharmaceuticals, gene therapy
2. **Industrial Biotechnology** - Enzymes and amino acid, organic solvent, organic acid, single cell protein
3. **Environmental Biotechnology** - Microorganisms for bioremediation
4. **Agricultural Biotechnology** - Enhanced crops, feed and fertilizers

Medical Biotechnology

- Pharmaceuticals: drugs, vaccines, monoclonal antibodies, stem cell

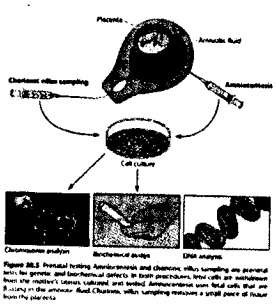
Medical Biotechnology

Diagnostics

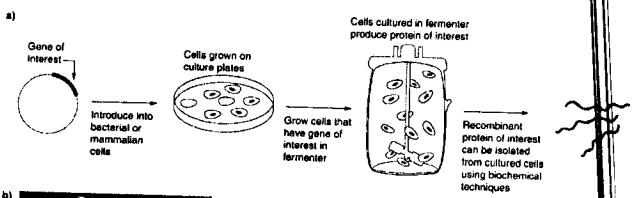


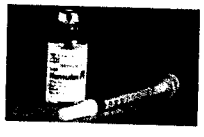
Medical Biotechnology

Prenatal diagnostics



Medical Biotechnology - Pharmaceuticals





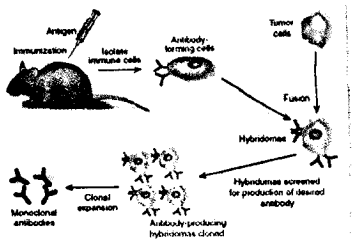
Production of Pharmaceuticals using recombinant DNA techniques

Medical Biotechnology – Pharmaceuticals

TABLE 1.2 EXAMPLES OF PROTEINS MANUFACTURED FROM CLONED GENES

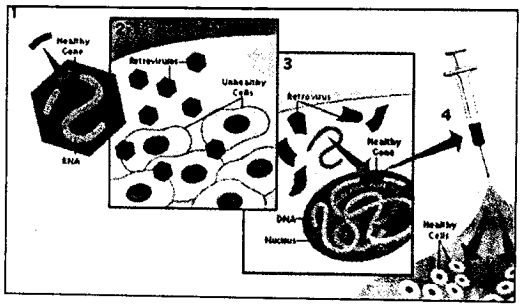
Product	Application
Blood factor VIII (clotting factor)	Treat hemophilia
Epidermal growth factor	Stimulate antibody production in patients with immune system disorders
Growth hormone	Correct pituitary deficiencies and short stature in humans; other forms are used in cows to increase milk production
Insulin	Treat diabetes
Interferons	Treat cancer and viral infections
Interleukins	Treat cancer and stimulate antibody production
Monoclonal antibodies	Diagnose and treat a variety of diseases including arthritis and cancer
Tissue plasminogen activator	Treat heart attacks and stroke

Medical Biotechnology – Monoclonal antibody

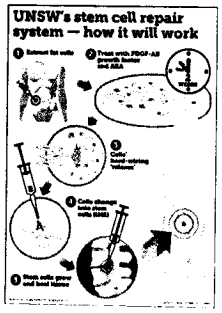


Production Of Monoclonal Antibodies

Medical Biotechnology – Gene Theraphy



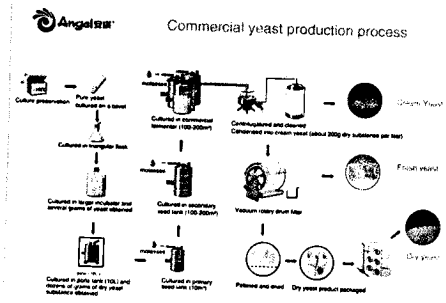
Medical Biotechnology – Stem cell



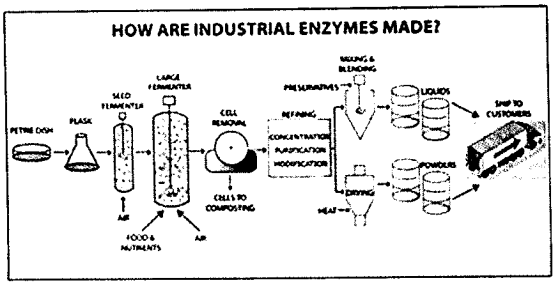
Industrial Biotechnology

- Cell biomass: bread yeasts, probiotics, single cell proteins
- Metabolites: organic acid, organic solvents, amino acids, enzymes

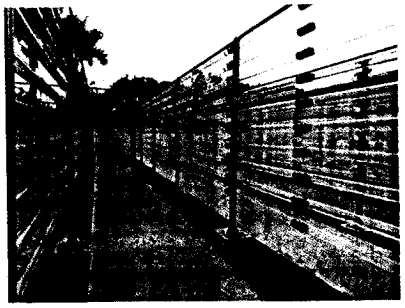
Industrial Biotechnology –Bread yeast



Industrial Biotechnology - Enzymes



Industrial Biotechnology - Algae

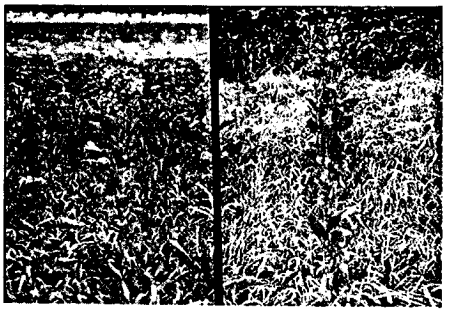


Agricultural Biotechnology

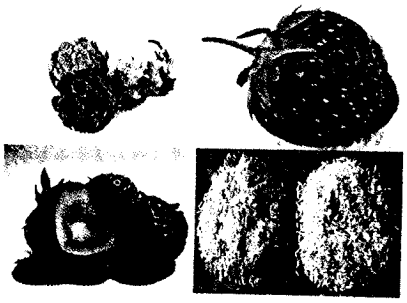
Genetically Modified Plants:

- Insect-, herbicide - resistance, Fixed nitrogen
- Improving nutrition (golden rice)
- Improving taste and beauty (seedless, beautiful colors, sweet ...)
- Enhance the processing and post-harvest process (tomato, mango) under harsh conditions: salty, drought tolerant ...
- Industry: increase productivity for oil, cotton, cassava, ...

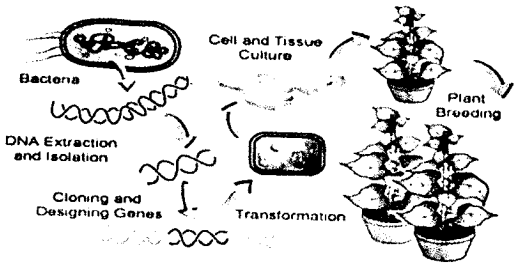
Agricultural Biotechnology - Herbicide tolerance



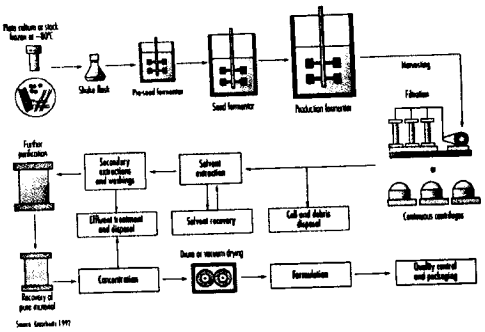
Agricultural Biotechnology - GMF



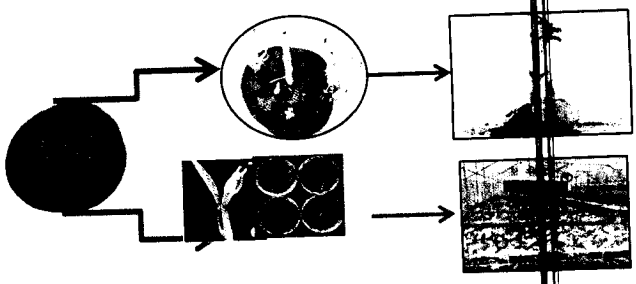
Agricultural Biotechnology – How GMO was made



Agricultural Biotechnology – BioFarm



Agricultural Biotechnology – Tissue culture

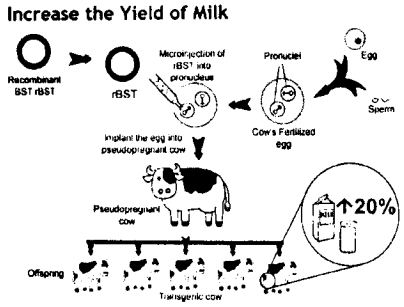


Agricultural Biotechnology – Trasgenic animals

Genetically Modified Animals:

- Transgenic Bovine Somatotropin (BST)
- Transgenic lactoferrin (HLF)

Agricultural Biotechnology – Transgenic cow



Agricultural Biotechnology -Transgenic chicken

Environmental Biotechnology - Phytoremediation

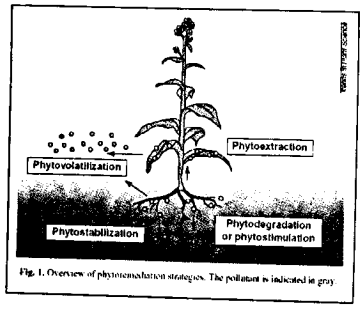
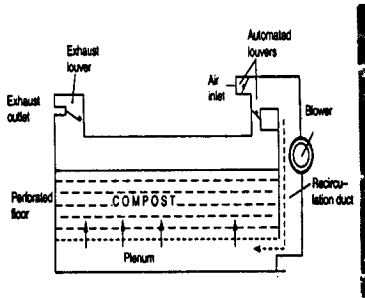
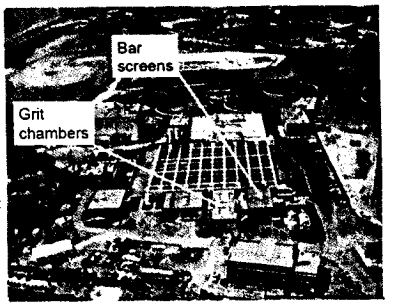


Fig. 1. Overview of phytoremediation strategies. The pollutant is indicated in gray.

Environmental Biotechnology – Waste treatment





Future Biotechnology

- Children will be produced in hatchery rather than born, be able to choose gene combination.
- Many techniques like Crytogenetics, Xenotransplantation, Proteomics, DNA microarrays add new horizons to the advancement of biotechnology.
- Protein based '***Biochips***' (which may replace silicon chips), ***Biosensors***, Nanobiotechnology, DNA buckyballs, Enzyme computers...