

FDE 330

FOOD BIOTECHNOLOGY

Bioprocesses

What is Bioprocess/Biotransformation/Bioconversion?

- ▶ Biochemical conversions which are catalyzed by microorganisms or enzymes are called as biotransformations or bioconversions.
- ▶ The industrial productions which are performed with the use of biological agents are generally referred to as «bioprocess».
- ▶ Biocatalysts in bioprocesses: **microbial cell/enzyme-free/immobilized.**
- ▶ Biocatalysts are definitely necessary for bioprocesses.

- ▶ Natural biological processes have been employed for food production since the early ages. Bread, cheese, yogurt, beer and wine, vinegar, and many other foods are produced through microbial fermentation or enzymatic activity.
- ▶ Although traditional fermentation processes, such as those involved in the production of fermented dairy products and alcoholic beverages, have been performed for thousands of years, it is less than 150 years ago that the scientific basis of these processes was first examined.
- ▶ It has been observed that microorganisms not only cause disease, but also perform different chemical reactions under appropriate conditions.
- ▶ With this biochemical conversion processes, it becomes possible to obtain products which are generally produced chemically.

- ▶ Biochemical reactions are generally easier and more economical than chemical reactions.
- ▶ Therefore, some products, which were formerly manufactured by chemical routes, can be produced by microbial fermentation more economically.
- ▶ Even some reactions which can not be performed by chemical routes can be carried out by fermentation (by bioconversion).
- ▶ For example, nowadays, several chemical compounds (especially antibiotics) are only produced by microorganisms via fermentation.

- ▶ **A vast range of important products**, many of which were formerly manufactured by chemical processes, are now most economically produced by microbial fermentation and biotransformation processes.
 - These include traditional fermented foods and beverages, such as bread, beer, cheese and wine, which have been produced for thousands of years. In addition, over the last hundred years or so, microorganisms have been further employed in the production of numerous chemical feedstocks, energy sources, enzymes, food ingredients and pharmaceuticals.

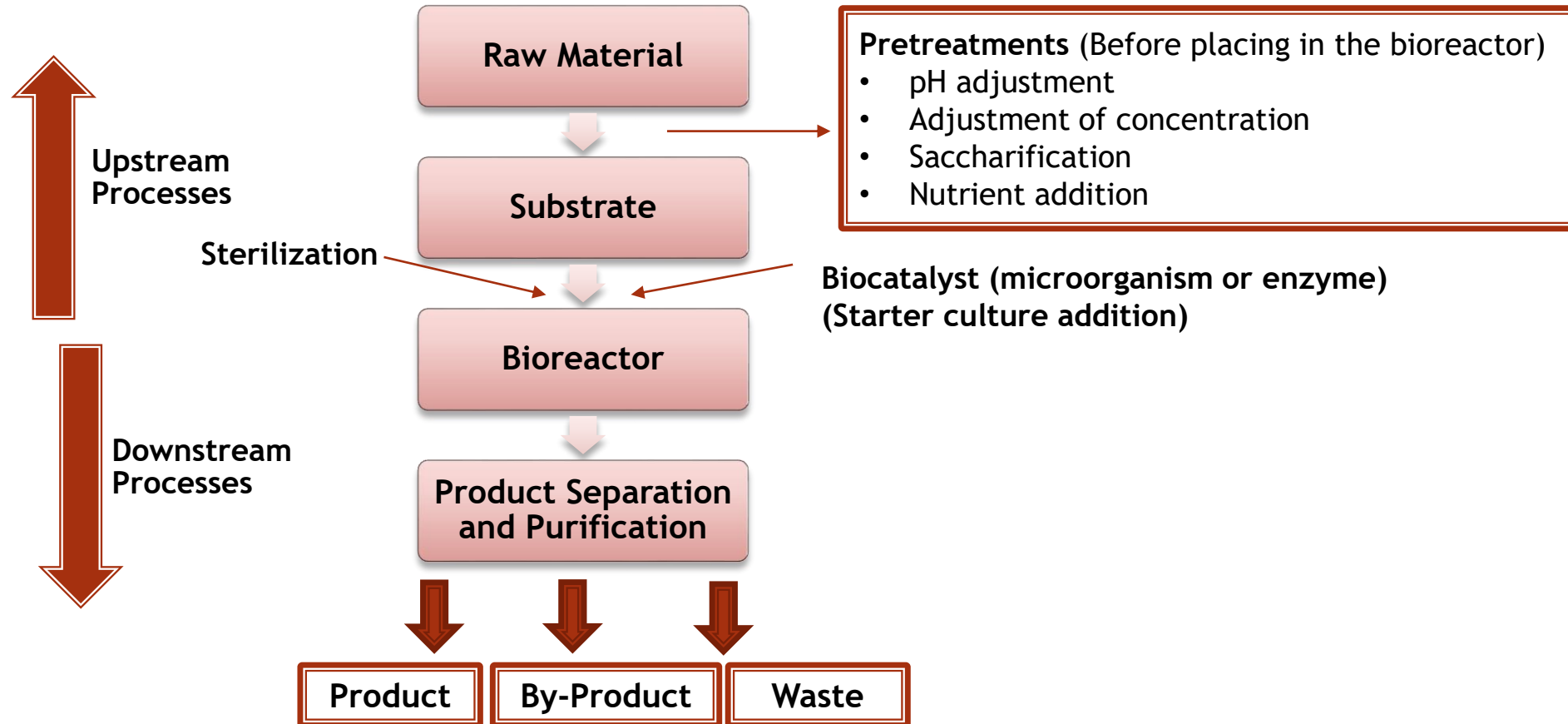
- ▶ Microorganisms also provide **valuable services**, particularly for waste treatment and pollution control.

- ▶ They have proved to be particularly useful because of;
 - the ease of their mass cultivation,
 - speed of growth,
 - use of cheap substrates that in many cases are wastes,
 - the diversity of potential products.
 - In addition, their ability to readily undergo genetic manipulation has opened up almost limitless possibilities for new products and services from the fermentation industries.

- ▶ Plants and animals as well as their cell cultures are also used in biotechnology. However, microorganisms have the following advantages over plants or animals as inputs in biotechnology:
 - i. Microorganisms grow rapidly in comparison with plants and animals. The generation time (the time for an organism to mature and reproduce) is about 12 years in man, about 24 months in cattle, 18 months in pigs, 6 months in chicken, but only 15 minutes in the bacterium, *E. coli*. The consequence is that biotechnological products which can be obtained from microorganisms in a matter of days may take many months in animals or plants.
 - ii. The space requirement for growth microorganisms is small. A 100,000 litre fermentor can be housed in about 100 square yards of space, whereas the plants or animals needed to generate the equivalent of products in the 100,000 fermentor would require many acres of land.
 - iii. Microorganisms are not subject to the problems of the vicissitudes of weather which may affect agricultural production especially among plants.
 - iv. Microorganisms are not affected by diseases of plants and animals, although they do have their peculiar scourges in the form phages and contaminants, but there are procedure to contain them.

In general, microorganisms are preferred for the reasons given above.

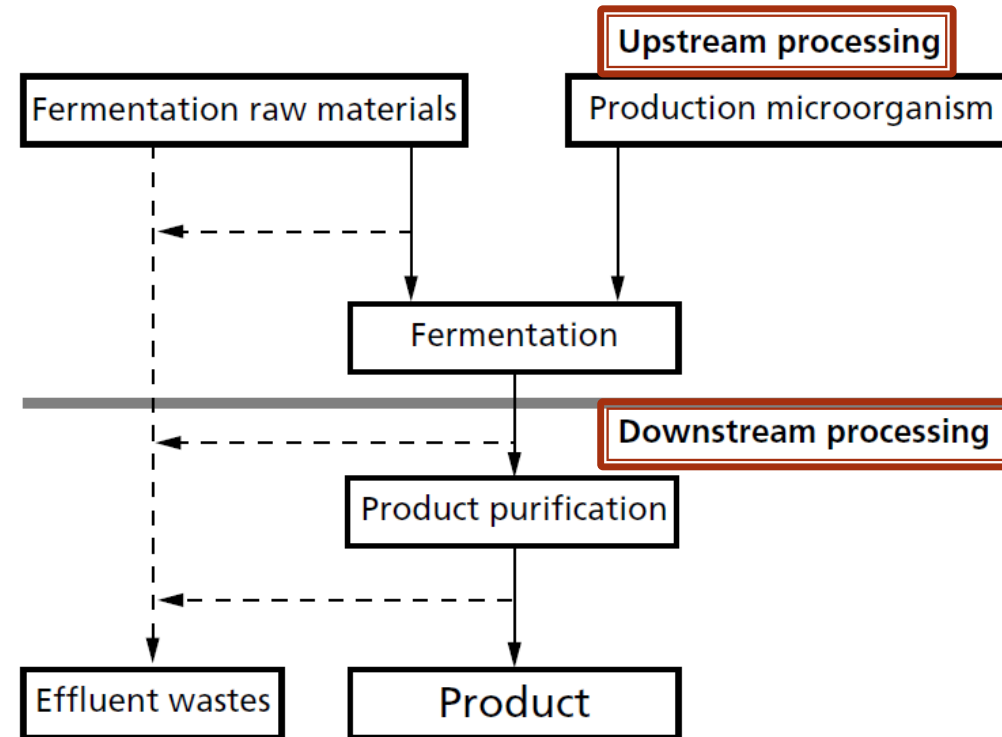
The Main Stages of Bioprocessing



What products or services can be obtained from microorganisms? (Important Industrial Processes)

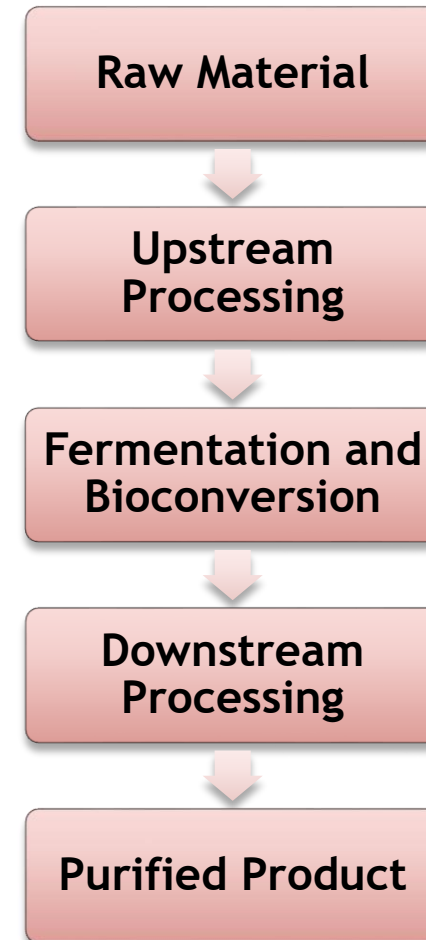
1. **Production of microbial biomass** (Baker's yeast or single cell protein production)
2. **Production of cell components** (enzyme or nucleic acid production)
3. **Production of metabolites** (These are chemical compounds such as ethyl alcohol, organic acids, antibiotics, vitamins which are produced as result of metabolic activity of cells.)
4. **Waste water treatment, leaching of metals** (e.g. Copper, iron, uranium and zinc) from low-grade mineral ores and wastes

Outline of a fermentation process



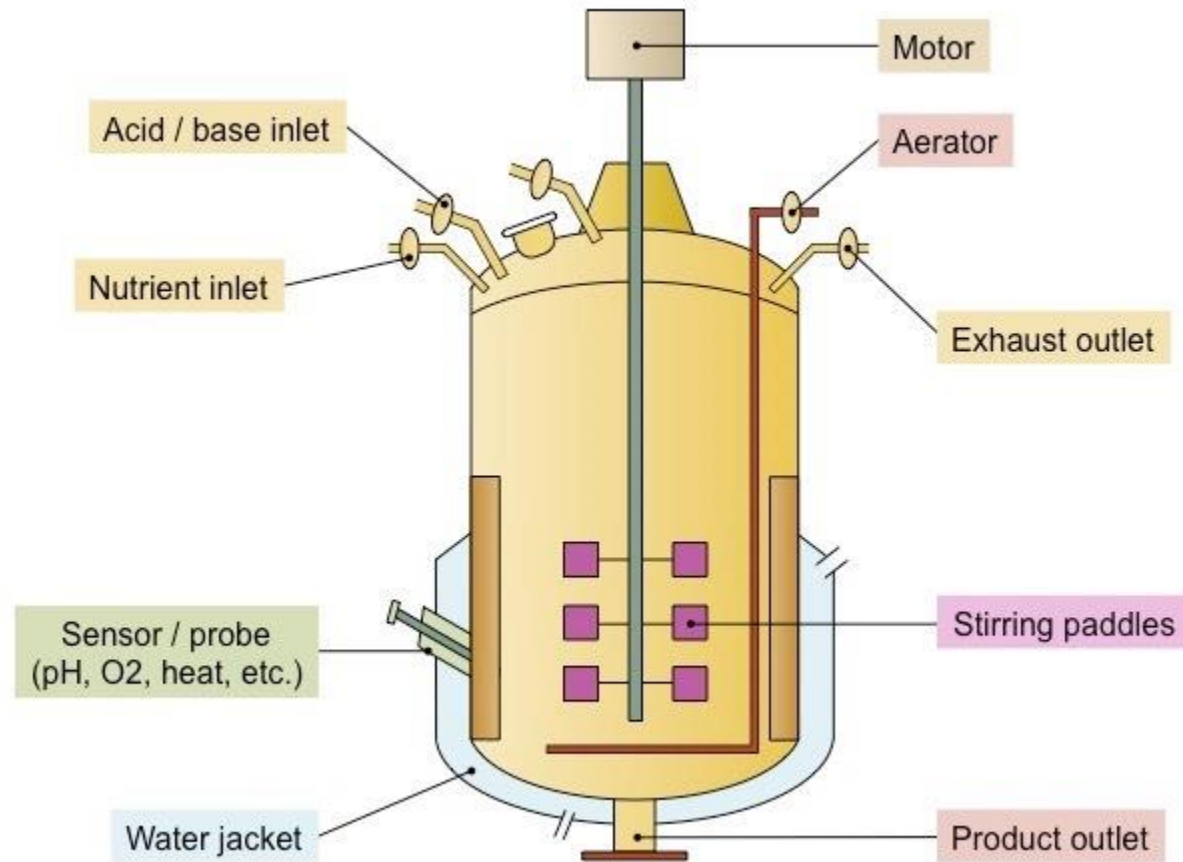
Outline of a fermentation process

- ▶ A typical operation involves;
 - Upstream processing (USP)
 - Downstream processing (DSP)



Fermenters

The vessel in which fermentation is carried out is called **fermenter**.



Fermentation Products

Food, beverages, food additives and supplements

- ▶ Dairy products (yogurt, cheese)
- ▶ Alcoholic beverages (beer, wine)
- ▶ Amino acids and vitamins

Fermentation Products

Health-care products

- ▶ **Antibiotics**-over 4000 isolated, only 50 used regularly
 - β -lactams, penicillins and cephalosporins
 - Aminoglycosides (e.g. streptomycin)
 - Tetracyclines
- ▶ **Other important pharmaceutical products**
 - alkaloids, steroids and vaccines
 - therapeutic recombinant human proteins such as insulin, interferons and human growth hormone

Fermentation Products

Production of microbial enzymes

- ▶ Extracellular hydrolytic enzymes (proteases, carbohydrases)

Industrial chemicals and fuels

- ▶ Industrial feedstock chemicals
 - Various alcohols, solvents such as acetone, organic acids, polysaccharides, lipids and raw materials for the production of plastics
- ▶ Fuels
 - Methane and ethanol, hydrogen, ethane, propane and butanol

Environmental roles of microorganisms

- ▶ Wastewater treatment, desulphurization of fuels, leaching of metals (e.g. copper, iron, uranium and zinc) from low-grade mineral ores and wastes using species of *Thiobacillus* and *Sulfolobus*, use of microorganisms to reduce usage of synthetic pesticides